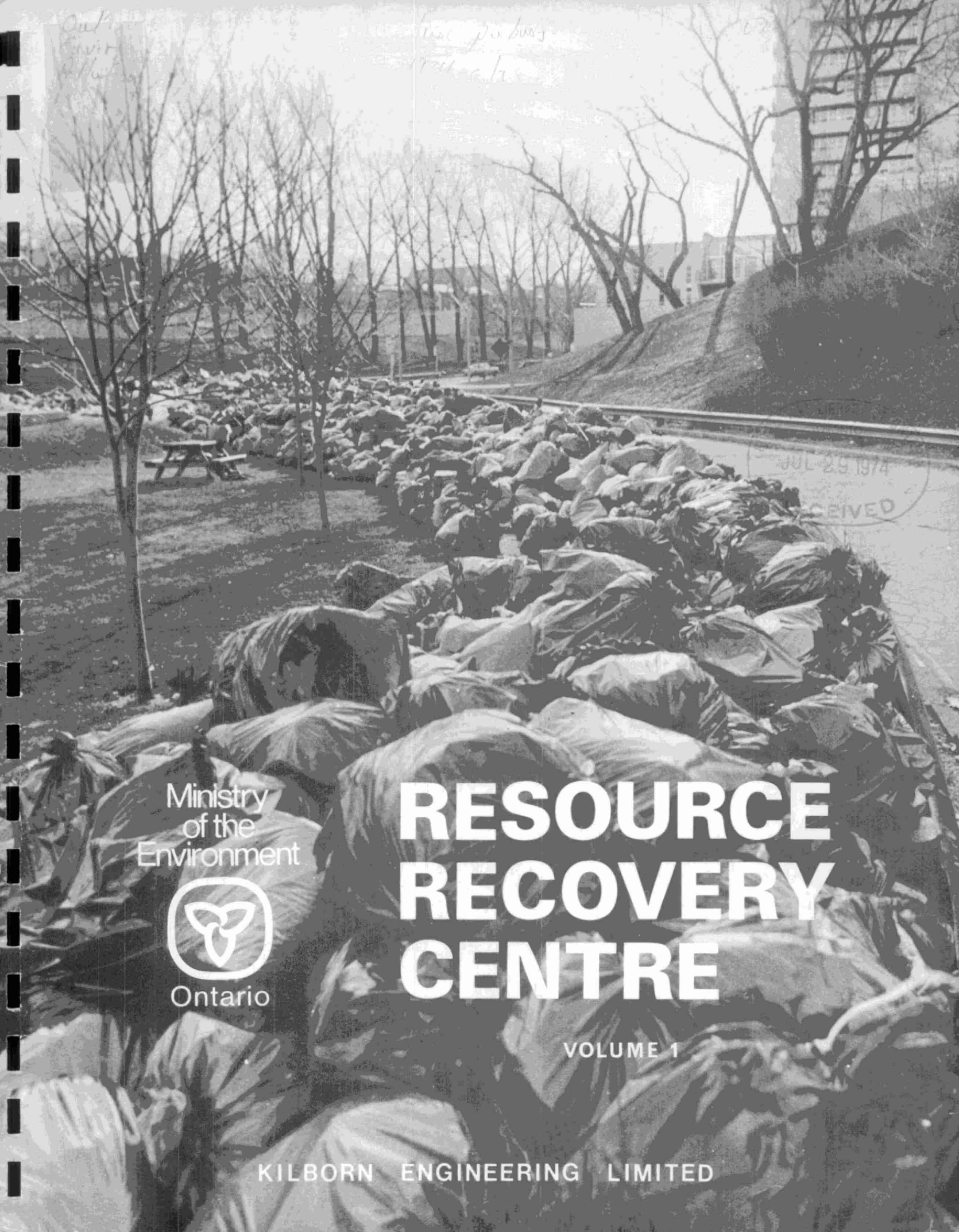

Ministry of the Environment

Ontario

RESOURCE RECOVERY CENTRE

VOLUME 1

KILBORN ENGINEERING LIMITED

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TORONTO, CANADA M8Y 3H8
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File: 982-15

April 25, 1974.

Ontario Ministry of the Environment,
880 Bay Street,
Toronto, Ontario.

Attention: Mr. W. Williamson,
Assistant Director,
Pollution Control Branch

Re: Proposal to Establish an
Experimental Reclamation Plant

Dear Sirs:

Following acceptance by the Government of Ontario of the proposal to establish an Experimental Reclamation Plant, the Joint Technical Committee for Resource Recovery appointed Kilborn Engineering Ltd. to undertake a study of refuse disposal through an Experimental Reclamation Plant, as the first step towards the development of Resource Recovery Centres.

In accordance with the agreement, we are pleased to submit the enclosed report with our findings and recommendations.

We appreciate having been given the opportunity to serve you and offer our continuing assistance as may be required to bring these proposed facilities into operation.

Yours very truly,

KILBORN ENGINEERING LTD.

J.D. Jones, P. Eng.
Manager - Environmental
Planning and Engineering.

JDJ/mf

C O N T E N T S

VOLUME I

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S E C T I O N 1

INTRODUCTION TO VOLUME I

CONTAINS
RECYCLED
DE-INKED
FIBRE

INTRODUCTION

1.1 PRESSURES FOR CHANGE

Considerable pressures exist for changes in the present methods of solid waste management because:

* Open dumping, which is still being practiced, is a contravention of our modern environmental, health and aesthetic standards.

* Landfill sites are becoming scarce and more remote.

* The quantity of solid waste generated amounts to about .7 tons per person per year and is increasing at a rate of 5% per year, (Toronto Growth Rate), all of which places severe strains on the municipal economics of collection and disposal.

* Citizens groups have become increasingly aware of the depletion and wastage of our natural resources with attendant environmental deterioration and are pressuring for more efficient utilization of our resources.

* Changes in makeup of solid waste are rendering present disposal methods less efficient and effective.

* New technologies and approaches are emerging which offer opportunities for greater economies in solid waste management.

1.2 GOVERNMENTS HAVE RECOGNIZED THEIR RESPONSIBILITIES

* For guiding our economies and energies in order to provide more efficient use of resources.

* For developing systems of information gathering and analysis to improve long term community planning and servicing.

* For providing incentives to stimulate the use of reclaimed products.

* For informing public and citizens groups of changing solid waste management approaches.

* For undertaking essential social improvement projects that are inappropriate and beyond the scope of the private sector.

1.3 THE BUSINESS COMMUNITY HAS RESPONSIBILITIES

* To co-operate with municipalities and with each other to develop standards of acceptability for reclaimed material and to re-channel the products into industry for re-use.

* To respond as good corporate citizens to use their energies in support of the preservation of our natural resources.

* To continue their prime role of developing new profit opportunities to be provided by innovations in reclamation technology in all fields.

1.4 OBSERVABLE COMMUNITY BENEFITS

Implementation of a solid waste reclamation system for a community of 100,000 (as an example), could expect a number of benefits and could effectively contribute to the preservation of our natural resources in:

* Conserving up to 3,500,000 gallons of fuel oil per year if burned as fuel, or
* Conserving up to 30,000 tons of paper and cardboard.
* Producing up to 3,600 tons of reclaimed steel for remelt every year.
* Recycling up to 4,500 tons of glass.
* Conserving up to 700 tons of aluminum, copper, lead and zinc per year.
* Saving 15 acres of land in the community for uses other than landfill.
* Realizing savings of up to 1/3 of the operating cost and up to 60% of the capital cost of incineration (without heat recovery).
* Allow immediate re-use of the landfill area due to rapid stabilization of the ground.
* Create new job and advancement opportunities.
* Increased flexibility for planning the uses of available public land.

1.5 GENERAL

To recover and utilize the components of solid waste, it is necessary to reprocess them to suit markets presently established or create new markets.

The segment of our society that can best serve us in this capacity is private industry which has the detailed technology, sales and marketing organizations, and access to existing markets, all of which are essential for redirecting the reclaimed products into our economy.

Solid waste, in its present form, is not suitable for use by industry, and requires some degree of preliminary preparation. We refer to this as "Primary Separation".

Before making the recommendations for the construction of an experimental solid waste reclamation centre, it was necessary to analyze the values obtainable from solid waste and to estimate the costs involved in recovering these values.

This analysis revealed that no segment could bear the cost of its own plant plus the cost of a primary separation plant. It may, however, in time be possible for all segments to contribute considerably to the cost of the primary separation module resulting in a possible future savings over the present disposal costs of solid waste as well as offering other benefits.

Preliminary studies also indicate that secondary modules attached to the primary separation plant could present interesting investment opportunities to industry if raw materials were obtained at minimum cost and no transportation charges were involved.

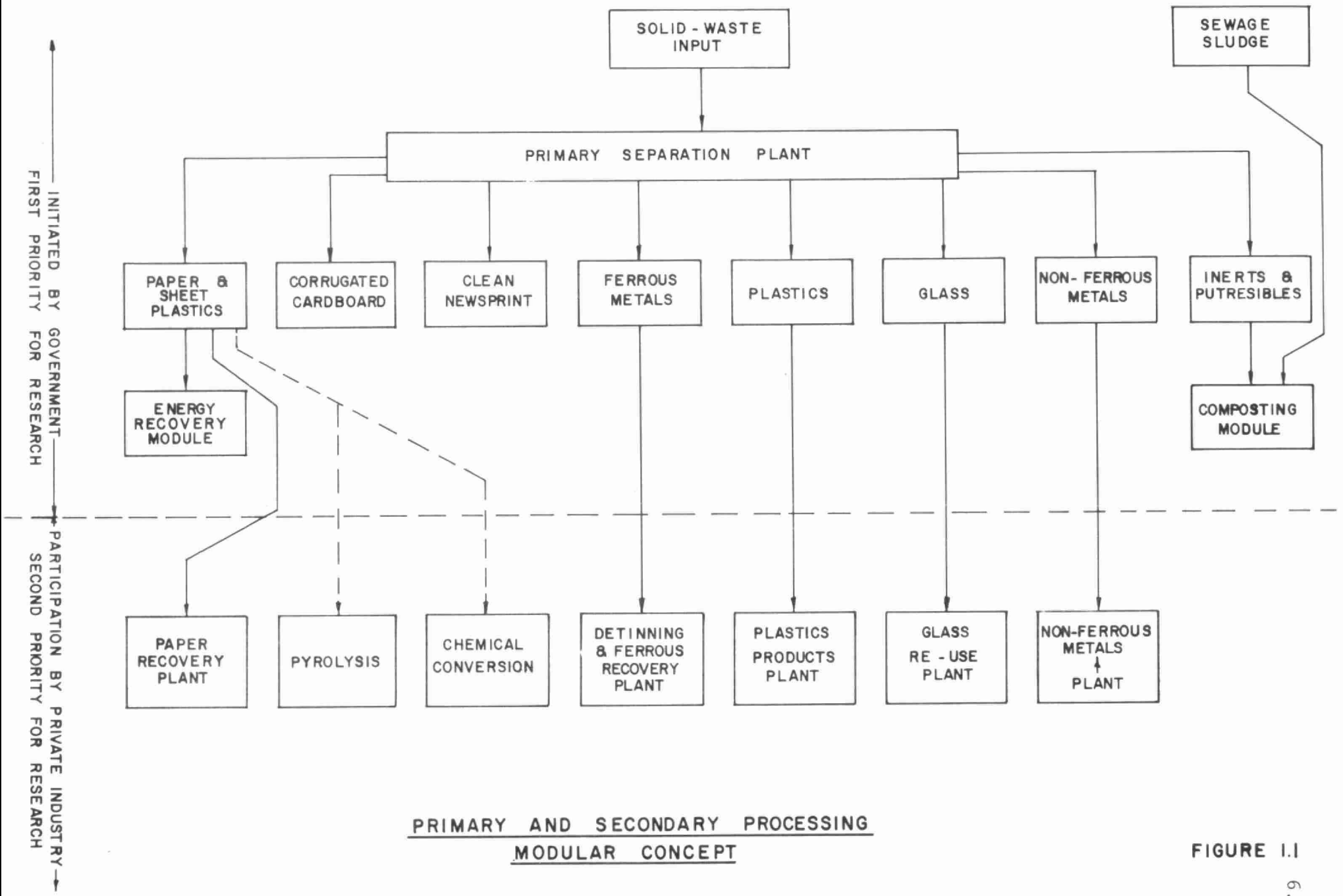
To achieve this objective, a modular plant concept has been developed to effect primary separation and which will yield products suitable for secondary processing modules.

Since neither the technology for the primary separation plant nor the technology for all secondary modules has been fully developed, the need for an experimental facility as a pre-requisite for establishing reclamation as an alternate to present disposal methods is a basic requirement.

Figure 1.1 shows the resources that will become available in quantity from the primary separation plant.

It was felt that the primary separation module, together with the composting and energy recovery modules, could best be operated through government initiative and as such would be the first priority area for research.

The balance of the secondary modules have been shown as requiring participation by private industry.



PRIMARY AND SECONDARY PROCESSING
MODULAR CONCEPT

FIGURE I.1

S E C T I O N 2

SUMMARY

SUMMARY

The study outlined in this report has been directed towards determining the technical feasibility of establishing an Experimental Reclamation Plant which would be capable of testing in practice the various technologies for the handling and processing of municipal waste.

The assessments made in the report have been in keeping with the defined objectives for an Experimental Resource Recovery Centre. These objectives are:

(a) To investigate and compare the suitability of alternative processes and equipment for the separation and reclamation of components from municipal waste.

(b) To determine the feasibility of separation and reclamation plants as an alternative to present methods of disposal.

(c) To examine the feasibility of staged or modular introduction of such plants.

(d) To investigate the additional processing required for the marketing of reclaimed materials.

(e) To investigate alternative outlets for such materials, and the methods and costs of handling.

(f) To develop criteria by which the capital and operating costs of various types and sizes of plants can be reliably estimated.

(g) To develop criteria by which environmental effects, including the consumption of energy, of reclamation can be gauged so that a reliable and complete comparison can be made between alternative processes.

(h) To provide facilities to other agencies and to industries for the installation and testing in practice of equipment, instrumentation, and processes related to their particular fields.

In order to accomplish the stated objectives, the processing of solid waste has been divided into two categories; (a) primary separation processes; and (b) secondary processing modules. By using this approach, it has been possible to design a primary facility to which any of the known or developing processes can be added as a separate module and which contains complete monitoring equipment to develop the necessary data for assessment. A Summation of each of the sections of the report follows.

Municipal Solid Waste Makeup (Section 4)

The average makeup of municipal solid waste has been determined to be as follows: (on a bone dry basis, moisture removed)

Combustibles	%	
Paper and Paper Products	50.0	
Food Waste	15.0	
Vegetation	7.0	
Plastics Rubber and Leather	3.6	
Rags and Textiles	2.6	
Wood and Miscellaneous	3.2	81.4%

Non-Combustibles	%	
Glass and Ceramics	8.4	
Ferrous Metals	6.5	
Non-Ferrous Metals	1.5	
Inerts	2.2	18.6%
		100.0%

Marketing (Section 5)

Present markets will accept clean corrugated cardboard and newsprint in the amounts generated by a reclamation plant. A limited market exists for tinned cans as obtained from a reclamation plant.

No markets presently exist for other separated materials.

Potential Markets

The most immediate potential market is the fuel market, particularly in view of present excalating fuel prices and shortages. While most of the work has been done with the large users, (i.e. power plants and cement plants), developments for using this material in power units as small as 1500 lbs of steam per hour are imminent.

The resulting broadening of this market base would have a very positive effect on the value of the combustible portion as fuel.

For the long term, however, the most lucrative market appears to be re-use of the materials, particularly paper, in something akin to its original form, i.e. newsprint or boxboard.

The material will, of course, require considerable secondary processing.

The study shows that resource recovery from mixed municipal wastes while not as yet self-supporting can, if given markets for recovered materials, compete with present disposal alternatives available to urban communities.

Technology (Section 6)

The technology for Primary Separation is well advanced so that it is now possible to operate a reasonably reliable primary separation plant with either a wet or dry process.

Energy Recovery Processes are quite well developed but problems still exist particularly in plant reliability. The most promising solution appears to lie in the utilization of the combustible fraction as a supplementary fuel as is being done by Union Electric in St. Louis.

More efficient primary separation resulting in uniform and higher B.T.U. content combustibles (8000 BTU vs 5000 BTU) has been achieved by Garrett Research and Metropolitan Waste Conversion.

It appears possible that this fibrous fuel product can be fired in small units at percentages as high as 60% to 90% of their total fuel requirement.

A variation of energy recovery processes is the conversion of the cellulose fraction to a combustible oil or gas but with a loss of fuel value in the conversion.

Material Recovery Processes

Technology for material recovery is in the developing stage. Black Clawson is able to recover some paper fibre from pulping solid waste. Alscope Consolidated has initiated research into the utilization of the total cellulose fraction for newsprint furnish and results look promising. Work performed by the U. S. Bureau of Mines on utilization of glass for insulation appears a distinct possibility, and processes for the recovery of non-ferrous metals have been successful in the laboratory.

In general, material recovery processes appear to offer the greatest promise of extracting higher values from solid waste.

Chemical Processes

Most of these centre around the conversion of the cellulose fraction into protein, alcohol, sugars, etc., and although they are in the laboratory stage, they offer the possibility of obtaining considerable value from waste. They are, however, competing with the cheaper established sources for these materials.

The study shows that Technology is not a significant barrier and that recycling offers the potential for an environmentally and economically superior alternative to many current disposal practices.

Research Program (Section 4)

The Research Program has been designed to develop processes, plants, markets, and economic data, and to develop a pattern of re-use of solid waste that will provide guidance and direction to reduce present disposal costs. The result will be maximum utilization of our resources, and preservation of our environment. Participation by Industries who may best utilize the recovered components is a necessary requirement for the success of all programs.

Equipment (Section 5)

Equipment has been selected on the basis of the flowsheets, and has been sized on the basis of past experience in the resource recovery field as well as on the research data generated by U.S. Bureau of Mines, Environmental Protection Agency, Greater London Council, England, and private industry.

Preliminary Flowsheet (Section 6)

The preliminary flowsheets have been prepared to carry out the functions and give the flexibility shown in the conceptual layouts. For the sake of clarity, monitoring and dust collection systems have been omitted.

Site Selection (Section 7)

For convenience of assessment of specific details, the study is referenced to an existing Metropolitan Toronto Transfer Station, Landfill Site or Incinerator Site, with consideration having been given to social acceptance, handling and available services.

Management (Section 8)

The Experimental Waste Reclamation Plant is to provide information through research. The direction which research programs should take may best be accomplished by a two-level management system, consisting of a Strategic Management and an Operational Management group.

Operating Procedures (Section 9)

Operating procedures will cover startup, alarms and communication systems, emergency shut-downs, safety, fire protection, and research programs.

Capital Cost Estimate (Section 10)

The capital cost to construct and equip a 200 ton per day Experimental Reclamation Plant is estimated to be $7,774,200.00

This may be broken down as follows:

Equipment	$2,882,000
Buildings	1,738,600
Yard	218,000
Land	1,000,000
Instrumentation	200,000
Electrical Distribution	560,000
Contingency	559,800
Engineering and Construction	615,800
Total	$7,774,200

Operating Cost Estimate (Section 11)

The gross annual operating cost is estimated to be $707,570.00.

The credits for recovery and disposal are estimated to be $270,440.00. The net annual operating cost is estimated to be $437,130.00 or on the basis of 52,000 tons per year a cost of $8.40 per ton can be expected of which Research and Monitoring is $3.55 per ton. This does not include amortization or transportation costs to and from the reclamation plant.

In conclusion the optimum long term solution to solid waste problems will probably be through the use of efficient, economical, centralized disposal facilities, each capable of processing all types of waste from a given area. Such large centralized facilities may find it economical to combine waste disposal with some degree of salvage as well as with recovery of a fuel value for energy conversion.

If recycling is not seriously carried out in Canada through a planned recovery centre, we may, through lack of awareness, encourage the recycling of foreign solid waste, leaving our own to accumulate.

An Experimental Resource Recovery Centre as proposed in this study could be the means of determining the guide lines for such a facility.

S E C T I O N 3

RECOMMENDATIONS

RECOMMENDATIONS

The recommendations discussed in this report are summarized as follows:

* That a full scale primary dry separation reclamation plant of 200 tons per day capacity be constructed as an ongoing research facility.

* That the initial plant include a paper and cardboard recovery and baling module, a metals recovery module, an energy recovery module, and a composting module.

* That the facility be laid out with provision for the addition of future experimental modules, which may be added without interruption to the process.

* The Experimental Reclamation facility should encourage present and future research of Secondary Processes and new Technology in conjunction with participants from industry who may contribute to the development of useful products.

* The plant should be fully monitored under operating conditions. Monitoring to include equipment function, operating costs, effluents.

* The Experimental Reclamation Plant should be located to form a part of an existing solid waste handling system. Ideal locations would be existing transfer station sites, Incinerator sites, or Landfill sites or a combination of them.

S E C T I O N 4

RESEARCH

RESEARCH AND DEVELOPMENT

4.1 INTRODUCTION

Research and development will be a key factor in reducing the difficulty of processing waste and promoting re-use. Such research will best be directed towards separation systems, methods of re-utilization, and the general improving of solid waste management technology and economics.

Progress in the field of solid waste management is unlikely to come from an immediate breakthrough that will remove all difficulties. It will more likely come from a series of step-by-step efforts directed towards solving one problem at a time.

It is recognized that a great deal of work has been done in the U.S.A. and other countries on waste handling, particularly with regard to secondary processes. This has not been directed towards a fully monitored reclamation plant of sufficient size to generate data required. Cost information is often times vague. There is no point in duplicating these past efforts, however, and care should be taken in concentrating new research to problems uniquely Canadian.

In the United States, as in Canada, there is increasing pressure towards recycling of solid waste. The present problem is to locate markets for reclaimed products. We should be aware that U.S. processors could

4.1 (Cont'd)

find a part of their market in Canada. This is already taking place to a small extent with high grade paper stock and scrap autos, two materials which have been successfully recycled for some time. If recycling work is not seriously carried out in Canada, we could encourage the recycling of foreign solid waste leaving our own to accumulate. An experimental reclamation plant established in Canada now will increase Canadian technology and put it in a position to develop and establish long term markets for recovered products. If work is not carried out in Canada, there is the danger that technology of volume reduction and resource recovery will later be imported, and may not then be directly applicable to Canadian needs.

It must be recognized that the resources going into the solid waste process are heterogenous masses of soiled municipal residue. It varies in composition from time to time and location to location. It does not lend itself to table top or pilot plant experimentation.

If the true nature of the handling and separation problem is to be evaluated, the resource cannot be scaled down or selectively gathered. The experimental plant must be equipped to handle all refuse as it is received if true knowledge and costs are to be projected. The recovery centre should be able to turn out clean,

homogeneous batches of product in a manner that the user industry favours, not one of his least requirements being a large steady supply of any raw material.

The reclamation plant then should be a full sized facility capable of an assured tonnage and a means to expand. It should not be considered as a scaled down operation.

It should be early recognized that the research function will be ever changing as the nature of waste is changing due to technological changes within the industries responsible for much of the product. The glass industry as an example is developing stronger light weight glass containers. The end result may be more units in the waste system, but less tonnage. "Thin-tin" is replacing conventional cans, again with a reduction in weight. These approaches in turn could have an effect on the present salvage markets. The techniques for separating wastes will become more complex as more and more combinations of different materials are used, i.e. foils laminated to fibrous materials, plastics fastened to board, aluminum fastened to tin or glass, etc.

4.1.2 Initial Operation

It is proposed that the initial operation should include modules directed towards paper, metal, energy, and compost recovery. These waste categories

4.1.2 (Cont'd)

collectively represent approximately 80% of the total volume of refuse coming into a plant. They also provide the most readily marketable products. As a result, when the total paper and metal content has been extracted, the quantity of waste requiring ultimate disposal will be greatly reduced.

The operation should start with a conventional separation module. The facility would then be improved to the best available standard serving as a research model for other communities and industry, all the time developing standard procedures and extracting cost data.

4.1.3 Continuing Research Benefits

Other benefits to be derived from the ongoing Experimental Resource Recovery Centre include:

4.1.3.1 The means to provide capital and operating costs on various processes and to develop optimum operating criteria. This would be available to any community considering reclamation, in part or total, as a method for handling solid waste.

4.1.3.2 Provide a means for testing waste from another area which might be considering reclamation, as an aid to optimizing new plant layouts. Without a means of analysis of present and future requirements, it

becomes difficult to develop a solid waste management program. The end result could be fragmented research on the part of a number of regions.

4.1.3.3 To provide a facility for training personnel as may be required by developing plants.

4.1.3.4 To provide accurate composition information pertaining to the percentage of each of the materials found in solid waste, considering seasonal and community variations, etc., and to provide accurate percentage recovery data.

4.1.3.5 To allow testing of processed waste to determine its attraction for birds and rodents and the degree of processing or composting required to eliminate them from disposal sites.

4 1.3.6 To provide an information centre and means for testing for those who design systems.

4.1.3.7 To provide public relations guidance to local authorities and encourage participation by industry and the private sector.

4.1.3.8 To set out design parameters and economic considerations for the design of equipment and systems, with emphasis on mechanization, reduced labour usage, safety, storage, collection methods, and transportation. To develop specifications for minimum performance of solid waste hardware.

4.1.3.9 To provide guidelines to government as an aid in drafting legislation for packaging, etc., which may enhance the recovery of values from solid waste.

4.1.3.10 To involve the necessary industrial participation in determining the design parameters for salvage of components such as paper, rubber, metals, glass, etc.

4.1.3.11 Through testing, it will enable optimization of present landfill sites and methods of transportation.

4.1.3.12 While the social stigma attached to "garbage collecting" has been reduced, the advent of a modern handling facility will be another aid in upgrading public thinking towards this important field.

4.1.3.13 It will provide the means for setting standards of sanitation required in plants of this type based on microbiological analyses of Pathogenic organisms at various stages of processing.

4.2 RESEARCH PROGRAM

4.2.1 General Objectives

The objectives of the Resource Recovery Centre was specified under the following eight items:

(i) to investigate and compare the suitability of alternative procedures, processes and equipment for the separation and reclamation of components of municipal wastes;

(ii) to determine the feasibility of separation and reclamation plants as an alternative to present methods of disposal;

(iii) to examine the feasibility of staged or modular introduction of such plants;

(iv) to investigate the additional processing required for the marketing of reclaimed materials;

(v) to investigate alternative outlets for such materials, and the methods and costs of handling;

(vi) to develop criteria by which the capital and operating costs of various types of plant of various sizes can be reliably estimated;

(vii) to develop criteria by which the environmental effects, including the consumption of energy, for reclamation can be gauged so that a reliable and complete comparison can be made between alternative processes;

4.2.1 (Cont'd)

(viii) to provide facilities to other agencies and to industries for the installation and testing in practice of equipment, instrumentation and processes related to their particular fields.

For the purposes of determining the requirements of research programs and deciding upon the basic equipment that should be available at the reclamation plant, it is desirable to condense these objectives under the following general headings:

(a) Evaluation of processes and equipment -- this covers items (i), (ii), (vii) and (iv) (partially) in the original objectives;

(b) Evaluation of the quantity, quality and potential cost of production of reclaimed materials -- items (iv) and (v);

(c) Transfer of technology developed at the Centre to other locations -- items (iii), (vi) (partially), and (viii).

The most basic requirements to achieve these ends are the capability of research programs to determine materials balances, materials quality, unit operating costs for reclamation, and the immediate

impact of the proposed approach on environmental quality in terms of potential water, air, and land pollution. Other necessary data would be supplied by market research on the finished reclaimed products.

4.2.2 Recommended Research Priorities

The order of priorities is based on the premise that the intent is to recover value from waste in the shortest possible time and effect the maximum decrease in the quantities to be landfilled.

Given the complexity and magnitude of the research problems that could be investigated at the Centre, clear experimental objectives and well established priorities will be required if experimental work is to succeed. It is suggested that the following order of priorities be used to organize initial experimentation, some of which can be concurrent.

* Establish an efficient basic operation.
* Develop effective and reliable parameters for an energy recovery module.
* Develop the economic and environmental parameters for composting.
* Carry out a program to optimize the separation of plastics from putrescibles, glass and inerts.

4.2.2.1 Plant Operation

First priority should be given to establishing an efficient basic operation. The earliest experiments should be compatible with a phase in which;

(a) plant personnel are becoming familiar with every aspect of the initially installed equipment;

(b) data collection on plant performance should include the start-up phase;

(c) initial material objectives should be the primary separation of paper, ferrous metals, non-ferrous metals, plastics, glass and putrescibles.

4.2.2.2 The concept of using waste as a supplementary fuel for energy generation rather than as a means of getting rid of a nuisance should be studied further, particularly as it could be applied to smaller communities and northern sites. Studies would involve fibre fuel preparation, maximizing heat output, package power plants, flame geometry, residue handling.

4.2.2.3 Composting

While composting has not enjoyed great success in North America, it is felt that additional research

could be done in conjunction with an agricultural group directed towards certain soil or food producing requirements. These studies could be with or without sewage solids or with or without agricultural or organic industrial wastes.

The value of compost in rough or refined condition as cover material for Sanitary Landfill may be determined. The effect of composted landfill on leachate, rodents, birds, etc., may be determined.

4.2.2.4 Ferrous Metals Recovery

While technology for recovery of the ferrous fraction is well established, market evaluation and product improvement are very important aspects of the research program.

4.2.2.5 Plastics Recovery

Previous technology has been directed more to the disposal of plastics rather than to its recovery. Since the most recent developments show considerable value to be obtainable from this fraction, separation equipment has been shown on the proposed plant layout.

Since this area will incorporate new techniques and methods, some research will be required to optimize the operation.

It would be realized that these proposed programs are presented only in concept form, each approach

4.2.2.5 (Cont'd)

will demand detailed planning and review before being brought to the stage of final experimental design and implementation.

4.2.3 Continuing Research

4.2.3.1 Research on the General Composition of Solid Waste

4.2.3.1.1 Objectives and Rationale

The objective of this research would be to provide accurate total quantity and compositional information on the percentage of each of the major materials categories found in solid waste. Consideration would be given to seasonal and community variations and long-term trends imposed by such changes as major developments of new packaging materials or other items ultimately disposed of to municipal waste.

It is fully realized that research in the reclamation facility must avoid duplication of past efforts. It is recognized that a great deal of work in the U.S.A. and other countries has been done and a number of waste management surveys carried out. However, some quotations from recent reports and reviews serve to illustrate the current situation with regard to quantitative data on total solid waste and solid waste composition and their applicability to Canadian needs.

Golueke writes, in a comprehensive review of the literature on solid waste management (Critical Reviews in Environmental Control, Vol. 3, Issue 3, p. 261, (1973): "Magnitude of the Problem -- Although one would have to make an extremely protracted and detailed search of the literature to find a paper or report that does not agree that the rate and extent of the generation of solid wastes is one of the more serious aspects of the solid waste management problem, he would be hard put to find more than a very few papers reporting firm numbers as to amount and composition of solid waste from any waste generator, and expecially from municipalities. It would be too time and space consuming to attempt to give a comprehensive list of publications to illustrate the tendency to quote "on faith" rather than on the basis of actual observation" (emphasis added). Golueke goes on to illustrate the extent of "tradition" (i.e. handing down of beliefs from generation to generation) in solid waste "statistics", and the magnification of the uncertainty due to projections of present and future nationwide production for quantities based on a value for per capita production which has its origin primarily in "tradition". His comments were made in the context of experience in the U.S.A. but are even more pertinent in relation to Canadian needs.

4.2.3.1.1 (Cont'd)

In relation to the composition of solid wastes generated in the Metropolitan Toronto area, studies were undertaken by J. F. MacLaren Limited (1967), Ontario Research Foundation (1971), Ministry of the Environment (1973), and Horner and Shiffrin Inc. (1973). With respect to the data of MacLaren and the two 1973 studies, the Ministry of the Environment report "Watts from Waste" states: "The data .... are not believed to be sufficient to warrant an attempt to determine trends in composition. Only a long-term program, under specifically controlled conditions, could be expected to provide sufficient data from which trends could be determined" (emphasis added). The same objections apply to the limited study by Ontario Research Foundation. Further to this, the few reliable sources refer to U.S.A. or European situations where social and climatic conditions are considerably different from those applicable to Canada.

The desired research program should be designed through careful choice of sampling and statistical methods to use data taken routinely and on specially selected sampling events to answer questions on total waste, variability in total waste, composition and its variability and the total quantities of

specific item types and their variability. Particular attention should be paid to such items as chlorinated plastics which should be monitored with great care due to general concern regarding their growing use and adverse environmental effects.

4.2.3.1.2 Implementation

The program would be carried out in the following stages:

(i) Definition of material categories would be established;

(ii) Design and evaluation of sampling procedures, taking into account work already carried out by other researchers;

(iii) Design of a data collection and storage system in which information on total waste quantities, seasonal and community characteristics and composition would be retained;

(iv) Continuous data collection on total waste quantities as affected by seasonal and source community characteristics. For this purpose, the data collection will have to be closely integrated with collection and transportation information;

(v) Periodic materials category sampling in relation to seasonal and source community characteristics;

4.2.3.1.2 (Cont'd)

(vi) Continuous data analysis, reporting, interpretation and updating of information to be made available on request to government, research, industrial and municipal users in Canada.

The critical operational factors in this research program will be the quality of the sampling procedures and effective data handling, these will receive particular emphasis in the total program design.

4.2.3.2 Research on Equipment Performance

4.2.3.2.1 Objectives and Rationale

Although many unit processes have been studied elsewhere, their performance has not been evaluated under integrated plant conditions and in particular under conditions whereby reliable cost information can be retrieved.

The objectives of this research will be to provide capital and operating costs on various unit processes. The emphasis will be on establishing optimum design parameters, economic considerations and operating criteria.

4.2.3.2.2 Benefits

(i) The data would be available as a planning aid to any community considering reclamation;

(ii) Minimum performance specifications for solid waste handling equipment could be written;

(iii) The effects of synergism or antagonism between primary modules would be known at an early stage of plant operation.

4.2.3.2.3 Implementation

This program will be carried out by continuously collecting data on equipment performance. The data will relate to production throughout, labor requirements, down time and service costs, power consumption, noise, air, and water emissions and operational efficiency (measured by the quality of the product obtained from each unit process under test). Initially, data records will be kept for the first phase equipment, as new permanent or test equipment is brought into commission, data from these will be included. A data handling, interpretation and reporting system will be designed to run from the first plant operations. This system will be reviewed and improved periodically with operating experience. It is essential that this data be available immediately from start-up of the plant since potential commissioning costs will be

4.2.3.2.3 (Cont'd)

critically valuable to any agency planning to install similar equipment.

To be operational from plant start-up, this program will require considerable advanced planning. Specifically, experience published by other workers and available through discussions with operators of existing systems should be assembled, analyzed and used to design the data collection and control procedures. This planning phase should begin immediately after final decisions on the equipment to be installed have been made.

4.2.4 Special Research Programs

Special research programs will be directed toward the production of quality marketable products from the waste stream. The heterogeniety and variability of municipal solid waste suggest superficially that reclamation is desirable into an extremely large number of categories. However, the system must be optimized between maintaining minimal cost with producing maximal quantity and quality of reclamation. Marketability of any reclaimed resource is a preliminary factor in choices between reclamation and disposal; it is determined by product usefulness, product quality, location and the cost of reclamation. The role of the proposed Resource Reclamation Centre would be to

provide the required data to determine the cost and technological methodology of reclamation of any component for which a market exists. This data will be collected from the reclamation plant under controlled but realistic processing conditions, i.e. carefully controlled pilot experiments designed around specific product objectives.

It is anticipated that the initial operation will consist of plant modules directed toward paper and metal recovery. In a more general sense, these may be considered as providing primary separation into organic (combustible) and inorganic (non-combustible) fractions. Three initial types of product research are, therefore, proposed: (a) preparation of combustible fractions and their evaluation as fuels; (b) preparation and evaluation of marketable recovered paper fibres; (c) preparation, segregation and evaluation of metal values.

4.2.4.1 Research Directed to Producing Useful Solid Fuels

4.2.4.1.1 Objectives

Burning the organic fraction of solid waste for its energy content is an immediately promising short-term approach to value recovery. There are a number of ways the utilization of heat values can be accomplished. Approaches have been made to using refuse as a supplementary fuel for power generation

4.2.4.1.1 (Cont'd)

(see e.g. "Watts from Waste") or in cement manufacture (E.E. Berry, O.R.F. Report to Air Management Branch, (1972)). Pyrolysis, gasification and wet oxidation also come under this category of utilization. These are excluded from the first phase of research planning, since all require extra equipment modules. Initially, the objectives will be to produce solid fuels.

The quality demanded of the fuels will vary according to the desired end uses. It will be necessary to develop knowledge of the inter-relationships between process parameters and the final nature of the fuel produced if future plants are to be designed to suit local markets. The proposed programs will, therefore, have as their objective the definition of fuel quality characteristics in relation to reclamation process variables.

4.2.4.1.2 Implementation

(i) By surveying potential markets, fuel acceptability criteria will be established in terms of thermal values (BTU/lb), ash content (non-combustible residue), softening and melting points, particle size, potential air pollution hazards, and transportability;

(ii) Necessary product sampling procedures will be developed;

(iii) Fractionation procedures and systems will be studied and their performance evaluated against these criteria. In particular, combination (synergistic or antagonistic) effects relating shredder and classifier characteristics to fuel value will be examined;

(iv) Practical demonstrations of fuel utilization will be conducted both on site and in full scale operation units. The production capacity of the Reclamation Centre will permit realistic demonstration experiments to be carried out far more simply than is currently possible.

(v) A close co-ordination will be maintained between the researchers concerned in these programs and workers involved elsewhere in projects studying incineration, burner engineering, and combustion system design.

4.2.4.2 Research Directed to Producing Usable Paper Fibres

4.2.4.2.1 Objectives

A very attractive long-term alternative to burning the total organic fraction is to recover and re-use

4.2.4.2.1 (Cont'd)

some of the fibre that it contains. The Black-Clawson system takes this approach; however, hydropulping the total waste stream does not appear to be the desired means to this end. A more realistic approach is to take as 'clean' an organic fraction as possible (obtained by dry separation) and obtain from this the maximum yield of pulpable fibre.

Waste papers may be placed into one of four separate categories based on their potential ease of defibration, which in turn is a function of the processes used in the manufacture of the original pulp. These same categories may also be extended to include a ranking of market values. Repulped fibres from the more readily repulpable materials being the least valuable in the market for reclaimed materials. There is, therefore, both a technical potential and an economic incentive for separation of these types of papers as efficiently as possible. This separation might be effected in two ways: (i) by controlled operation of the primary classification system; (ii) by controlled operation of a repulping process. When optimum separation was available, research would be required both into reducing contamination by other garbage

components such as fats, foodstuffs, etc., and into the repulping of more recalcitrant papers.

B. G. Baker of Stanford Research Institute in his Long Range Planning Service Report -- "Recycling" states: "Currently, waste paper in mixed municipal refuse has no economic value because of the inability to segregate adherents and contaminants". The proposed research programs are addressed to the alleviation of this situation.

The objectives of this work would be the production of the most economically valuable paper fibre raw materials, and the demonstration of their quality, potential quantity, marketability and likely cost of production.

4.2.4.2.2 Implementation

This program concept combines a number of quite large sub-programs. As conceived, they have common requirements for (a) a small scale hydropulping unit (see section 4.6.3.3) and (b) the availability of extensive paper testing facilities to which potential raw materials can be transferred for very detailed evaluations. In outline, the approach recommended would be as follows:

(i) A program of controlled investigation of primary process variables (probably

4.2.4.2.2 (Cont'd)

integrated with experiments related to fuels production) will be made. At each stage, a quantity of the material will be hydropulped and evaluated as a paper fibre raw material.

(ii) Sampling procedures will be developed and tested.

(iii) Material will be taken from the most efficient primary separation process (which may not be the best process for paper production but may be better for other functions) and examined by hydropulping under various conditions. Again, yield and quality will be evaluated on the final products.

(iv) Following extensive laboratory research, methods of reducing contamination and of re-pulping recalcitrant papers would be developed to pilot scale on site.

4.2.4.3 Research Directed to Metals Recovery

4.2.4.3.1 Objectives and Rationale

Of the 8% to 10% metallics commonly found in municipal refuse, some 90% are ferrous and much of the recoverable remainder is accounted for by aluminum. Initial objectives for research will, therefore, concentrate on these two types. The

marketability of metal scrap is largely determined by 'cleanliness' of the product. In the context of municipal refuse, two kinds of contamination are pertinent. Firstly, contamination of metallic components by non-metallic residues. Secondly, contamination of one metallic species by another through alloying, coating, physical attachment or accidental admixture. Contamination by non-metallic residues, physical attachment and accidental admixture are the most likely to be tractable to separation procedures. Because of their relatively high value and because of the many years of experience in reprocessing scrap material from metals process industries, much work has been done in research on metals recycling. For example, the U.S. Bureau of Mines has an extensive program of research in operation on recycling metals from refuse. It is difficult, therefore, to design programs in this field in the absence of clear specification requirements from potential users. It is anticipated that research objectives will be directed initially to obtaining clean ferrous and aluminum fractions from the primary air classifier rejects. The problems of meeting specification requirements relating to alloying and coating and the problems of secondary metallurgical processing would be more properly examined at later stages in a fully equipped metallurgical research establishment.

4.2.4.3.2 Implementation

(i) User specifications will be obtained by market research;

(ii) Separation of ferrous metals will be examined using magnetic fractionation;

(iii) Wet and dry methods of separating aluminum from the mixed non-ferrous rejects will be examined using such approaches as sink-float separation, air classification, electrostatic separation and flotation. Initially, these experiments will be carried out on small scale laboratory equipment. Scale-up to larger operations will follow as soon as feasible approaches are identified;

(iv) Promising approaches published in the literature or suggested by the work of other researchers will be examined and if thought feasible, will be tested at the research facility. Emphasis in such testing will be given to practicability and cost effectiveness.

4.3 SAMPLING PROCESS MATERIALS

The key to reliable quantitative analysis of any materials handling process is in the quality of the methods chosen for extracting samples for subsequent examination. Solid waste in the raw state is not only complex in composition, but because of source,

season, social and economic factors, it is also a variable material. As processed, some of the variability and complexity will be reduced by mixing but the problem of obtaining homogeneous samples for detailed study will remain.

4.3.1 Sampling Locations

A means of materials sampling should be provided at each input point, each transport stage between unit operations and each product output point. Sampling in this context must include both quantity measurement, (e.g. weight per unit time) and extraction of material for subsequent detailed examination. Projected sampling locations are shown on Kilborn Drawing No. 982-130-6.

4.3.2 Sampling Methods

Soundly based statistical sampling methods must be adopted from previously published work or must be developed through experimentation at the research facility. Sampling methods will be different for each of the three types of sampling locations corresponding to the three material types (raw, part processed and finished).

4.3.2.1 Sampling Raw Refuse

Workers at the U.S. Bureau of Solid Waste Management have presented procedures for sampling raw wastes at the point of delivery. These should be examined

4.3.2.1 (Cont'd)

in detail by discussion with these researchers and observation of sampling procedures in progress. If considered applicable, they should be used as a basis for developing standard sampling techniques. The lack of available sampling methods for raw refuse is only a special case of the general lack of adequate methods for many bulk materials handling processes. In almost all aspects of bulk sampling (with the exception of coal and fertilizer industries), there is a great need for empirical research on sampling procedures, sampling statistics and sampling devices. To this extent, important research on sampling with emphasis on the special needs of refuse handling problems will need to be carried out at the Reclamation Centre and in programs associated with the Reclamation Centre.

4.3.2.2 Sampling During Processing

In general, sampling material during processing will require that samples are withdrawn not from a discrete bulk batch but from a flowing stream either on a conveyor or in a pipeline or other transport device.

Sampling methods for part processed wastes will require development, drawing on established

procedures from other areas of materials handling, (e.g. mining, soil science, powder technology, mineral processing and coal industries). Split-stream sampling should be avoided due to possible selective segregation in materials with a wide range of densities and particle size. Incremental samples at fixed time intervals each comprising a complete cross-section of the transport stream should be used for collecting materials between unit processes. Wherever possible, these sample increments should be taken at points where the material is in a free-fall state.

4 .3 Sampling of Finished Products

Each type of finished product will require development of suitable sampling techniques. Where possible, established procedures relevant to the product, such as ASTM recommended methods, will be used. Where these are not available or not suitable, new methods will be developed.

As is apparent from the foregoing discussion, much basic work is required on sampling procedures. As much as possible of the necessary experiments to implement these requirements will be integrated with both continuing and special research programs (see sections 4.2.3 and 4.2.4). As will be seen, each of these programs has an associated sampling

4.3.2.3 (Cont'd)

development requirement included. Available bulk sampling equipment should be surveyed and the most promising types subjected to exhaustive in-plant testing. This will determine that not only is the best equipment brought into routine service, but that the choice of sampling methods in other subsequent facilitiés can be based on a comprehensive study of available equipment.

4.4 PLANT EFFLUENT MONITORING

Since one of the prime requisites of any new solid waste processing plant is that it should meet all air and water effluent standards in the jurisdiction in which it is located, it is essential that good data be generated on the effluents from all processes in the experimental plant. These data will allow an accurate prediction of the effluents from any subsequent plants based on technology developed at the experimental recovery unit.

4.4.1 Air

Any exhausts from the experimental plant should have stacks whose height is at least ten times the stack diameter. Two four inch sampling ports should be located at 90° to one another, at least eight diameters downstream of any bends, fans, etc., and at least two diameters upstream of the stack exit.

A platform allowing access to the sampling ports should be located approximately four feet below the ports, and should be at least three feet wide. These ideal sampling locations will greatly facilitate air emission monitoring especially for the determination of particulate emissions.

All sampling of air effluents will be done according to the Ontario Source Testing Code (Ontario Ministry of the Environment, January, 1973). This will require a commercial sampling train such as that manufactured by Joy Manufacturing which allows isokinetic samples to be taken of both particulate and gaseous effluents, and at the same time measures the flowrate of the effluents in the stack.

Carbon dioxide, carbon monoxide and oxygen contents of the effluent gases will be measured using an Orsat analyzer. Nitrogen oxides are collected in special evacuated flasks (described in the Source Testing Code) containing diluted sulphuric acid and hydrogen peroxide. Subsequent analysis is performed colourimetrically. Hydrocarbon emissions should be monitored using a continuous hydrocarbon analyzer such as the Temtron IPM. All other gaseous elements are absorbed in suitable absorbent liquids in the impinger sections of the sampling train.

4.4.1 (Cont'd)

It may be desirable, from time to time, to measure the odour threshold of effluent streams. Samples for this analysis are collected in Tedlar bags in a special sample "lung". The bag is connected to a teflon sampling line which is inserted into the stack through a sample port. The bag is then placed in the "lung" which is evacuated causing the bag to swell and draw a sample into itself.

As well as knowing the total weight of particulate being emitted from any process, it is also desirable to know what size that particulate is. This is important from two points of view. Firstly, if additional control of emissions is required, a knowledge of size distribution is essential, to properly choose the right equipment. Secondly, the fate of particulate emissions in the air is dependent upon their size; large particles tend to fall out quickly whereas smaller ones are entrained in the air and disperse with the gaseous emissions from the process.

Particle size distribution should be measured using an Anderson Stack Sampler, which is a cascade type impaction device, separating the particles into eight fractions according to their aerodynamic particle size.

4.4.2 Water

Any water streams coming from the plant should have tapped locations at which point a sample may be withdrawn. It may also be desirable to continuously monitor a particular stream for a specific contaminant (say chloride), using a specific ion electrode. A plugged "T" piece in the line would allow the insertion of an electrode or other monitoring device.

A source of water samples outside the plant will be from a landfill leachate test site. It is important to determine the acceptability of various product streams from the experimental plant as landfill.

In the future installations of processing plants based on technology developed at the experimental plant, local market conditions may suggest that some fractions will have to be dumped. Landfill leaching experiments may prove that some fractions of the waste stream are sufficiently clean to be dumped on sites which would not normally be acceptable for landfill because of drainage into a watercourse.

The type of test facility envisioned would be a mini-landfill contained in an area approximately 10 feet x 10 feet. The design would allow for the

4.4.2 (Cont'd)

inclusion of subsoil, waste and top soil above a washed gravel base, below which would be a take-off for the leachate. A conceptual sketch is shown in Figure 4.1. Natural rain water or artificially induced "rain" would be used to wash through the "landfill".

4.5 PLANT INSTRUMENTATION AND OPERATIONAL DATA COLLECTION

The experimental nature of the plant makes it imperative that all processes be fully instrumented to provide data that can be used in subsequent installations. Of particular interest are parameters which will directly affect the economics of the process, such as power consumption, operating labour requirements, maintenance schedules, throughput, etc.

Obviously, huge amounts of data will be generated, making it imperative to design a data storage and retrieval system that will allow efficient data processing. It is proposed that a computer system be set up for data storage. While the initial set-up time for the program, etc., may be longer than that required to set up a paper filing system, the long term flexibility of the system will more than compensate for the front end costs. A time-sharing computer terminal should be located in the laboratory,

plant data being fed in at the end of each day or week.

4.5.1 Operating and Maintenance Labour Input

This may be difficult to record. It will require good co-operation from operating staff with something like a punch-clock system for whenever they are working on a particular unit. Some time will have to be spent explaining that these records are not a "time and motion" study on them, but data required for analysis of the efficiency of a particular unit process in the plant.

4.5.2 Maintenance Supplies

A stores withdrawal system will be needed to keep track of supplies required for process maintenance.

4.5.3 Plant Operating Time

A cumulative clocking of total time of operation of each unit will be required to assess reliability of a plant when this is compared with the maintenance schedules.

4.5.4 Plant Throughput

All process streams should be weighed so that plant throughput can be monitored. Continuous conveyor scales such as those described in Perry (Perry J.H. "Chemical Engineers Handbook", McGraw Hill, 1963) should be installed. These are scale balanced

4.5.4 (Cont'd)

sections of belt conveyors used to totalize continuous loads. The totalizer integrates instantaneous loads with belt speed to take care of any belt speed variations. Points at which weighing should be made are shown on Kilborn Drawing No. 982-130-6.

4.5.5 Power Input

All electrical motors on process equipment, conveyors, and blowers should be equipped with Watt-hour meters to determine power input to each unit. Ammeters should also be installed to determine maximum current drawn on start-up or on stalling.

4.5.6 Noise and Vibration Analysis

A DBA meter should be available at the plant to check noise levels of equipment being used, to determine whether these levels meet industrial health specifications.

Vibration and strain gauge analysis on process components may be necessary from time to time. It would probably be better to contract this work out when it is required.

4.5.7 Pressure Drops and Gas Flow Rates in Pneumatic Systems

Pressure drops across pneumatic systems and across equipment such as the classifier or cyclones should be

measured using manometers or magnehelic gauges.

Flow rates should be measured in a section of the pneumatic systems not containing solids. Orifice plates or annubars could be used for this purpose. If an orifice plate is used, allowance should be made in the calculation of blower horsepower for the permanent pressure drop across the plate.

In some instances, it might be desirable to classify using hot air, to effect drying of the shredded garbage. This would require the installation of thermocouples in the gas streams. It may also be useful to measure relative humidity into and out of the classifier using hygrometers.

4.5.8 Combustion Units

Requirements for instrumentation of combustion units will vary with their design. In general terms, requirements will be:

- Optical pyrometers for flame temperature;
- Air and fuel feed measurement;
- Excess air measurement by oxygen meter in the outlet;
- If steam is raised, steam temperature, pressure and flow rate should be measured;
- Effluent measurements will be made using the stack sampler;
- Thermocouples will be used to measure exit gas temperatures.

4.5.9 Wear Analysis

While equipment like the hammers in the hammer mill wear very quickly, most other equipment requires many hours of running before this drastic a degree of wear is noticed. It may be that the experimental plant will not run for long enough to effect breakdown of most pieces of equipment. In these cases, a method of estimating wear, and hence predicted useable life may have to be developed. For example, conveyor belt thickness after 5,000 hours running compared to new belt thickness should allow extrapolation to the end of the belt's useful life.

4.5.10 Individual Recovery Units

Instrumentation required for the individual recovery units such as the ferrous metals treatment plant will be designated as the treatment plant itself is designed, and therefore, cannot be included in this report.

4.5.11 Truck Weigh Scale

A truck weigh scale will be required both for raw refuse feed material and for product shipment measurements.

4.6 LABORATORY REQUIREMENTS

Two alternative approaches could be taken to designing the laboratory facility for the experimental waste recycling plant. The first would be to have

a laboratory that was entirely self-sufficient, able to handle any analysis that might be required. The second alternative would be to have a laboratory that was capable of carrying out all the basic procedures required, but relying for more sophisticated work on laboratory facilities presently available in Southern Ontario. It is our opinion that the second alternative is preferable and that the following practical operational problems would be avoided:

(i) It would be impossible within reasonable capital limits to cover every possible requirement, without a huge investment in equipment;

(ii) It would be foolish to have expensive and sophisticated equipment being used only occasionally;

(iii) Operation and maintenance of such equipment requires a large staff of experts who would be grossly underemployed.

Therefore, it is assumed in our analysis of laboratory requirements that only a small amount of specialized analytical equipment will be located in the site laboratory, other analyses and testing will be contracted out to other laboratories. Equipment

4.6 (Cont'd)

to perform all the routine day to day analyses will, of course, be located at the site laboratory.

4.6.1 Laboratory Equipment for Basic Waste Analysis

The general layout of the laboratory is shown in Figure 7.2. This module will house almost all of the equipment required for routine analysis. Outside in the plant, requirements will be a large drying oven, capacity 200 - 300 lbs. and an area close to the receiving line, where samples of raw refuse can be taken and sorted. Major equipment requirements for the laboratory are discussed below with reference to the various analyses which have to be performed. Much of this information is drawn from "Physical Chemical and Microbial Methods for Solid Waste Testing", (NTIS Document PB 220-479). Each piece of equipment is only listed once, e.g. a drying oven is required for most operations but is only listed in section 4.6.1.1.

4.6.1.1 Sample Preparation

After samples have been taken from the various streams in the plant (see section 4.3), they must be prepared for analysis. The three basic operations required to prepare solid waste materials for subsequent detailed analysis are drying, grinding or pulverizing, and mixing. The end products of these operations

should be so thoroughly homogenized that portions weighing as little as 200 mg may be analyzed with full confidence that they are uniform and representative.

Moisture content of raw garbage will be determined on large samples in an oven of about 300 pound capacity.

Equipment to perform the required operations includes:

- Large industrial drying oven - capacity 300 pounds;
- Laboratory drying oven;
- Large scales - capacity 1000 pounds;
- Balance laboratory heavy duty - capacity 10 pounds;
- Balance single pan - capacity 100 - 200 grams;
- Dessicator cabinets;
- Heavy duty shears;
- Sample splitter;
- Laboratory hammer mill;
- Wiley mill;
- Pulverizing mill;
- Ore pulverizer;
- Set of standard sieves;
- Sieve shaker;
- Mixer;
- Bag dust collector;
- Miscellaneous pans, scoops, funnels, containers, brushes, etc.

4.6.1.2 Total Heat of Combustion

It will be necessary to determine the heat available in samples from various stages of garbage processing. To determine directly the heat available, calorimeters are employed. A partial list of equipment required follows:

- Parr adiabatic calorimeter;
- Parr double valve bomb calorimeter;
- Calorimeter accessories, fuel capsules, water heater, thermometers, fuel pelletizer;
- Laboratory glassware;
- Large capacity bottles;
- Stopwatch;
- Tubing rubber, plastic, glass.

4.6.1.3 Ash Content and Weight Loss on Heating to 600°C

Any product from the plant which would be utilized subsequently as an energy source, should have the ash content determined. Other products such as metals or glass fractions should also be analyzed to determine the quantity of combustible material remaining in these fractions. A modification of the procedure proposed by the American Public Works Association will be used for these determinations (A.P.W.A. "Municipal Refuse Disposal", 1966).

Major equipment items include:

- Lindberg Hevi-Duty muffle furnace;
- Porcelain crucibles;

- Tongs;
- Asbestos gloves;
- Reagents, inert standards and combustible standards.

4.6.1.4 Gravimetric Determination of Carbon and Hydrogen in Wastes

A complete combustion train is used to determine the carbon and hydrogen content of any samples of raw refuse or partially treated refuse. The essential elements of the train are shown in Figure 4.3.

Major equipment items required include:

- Lindberg furnace modified, combustion, organic, multiple tube type;
- Combustion barges, nickel and clay;
- Oxygen cylinder;
- Rotameter;
- 38 inch Vycor combustion tube;
- Impingers;
- General laboratory glassware;
- Absorption bulbs;
- Gas washers;
- Chemicals indicated in Figure 4.4;
- Retort stands, clamps, etc.

Alternatively, a Coleman carbon hydrogen analyzer could be used, which is based on similar principles to the test described above.

4.6.1.5 Nitrogen Content

Nitrogen is a significant parameter in solid waste composition. The change in C/N_2 ratio of compost can be used to determine the degree and rate of biological decomposition of organic matter in the compost and the suitability of the final product for use in agricultural soils.

The most convenient method of analysis would be by the automated Dumas method as employed by the Coleman nitrogen analyzer. Using this equipment, a sample analysis can be made in 15 minutes. The classic Kjeldahl method could be used, but this is much more time-consuming.

Major equipment required for the automated method includes:

- Coleman model 29A nitrogen analyzer, complete with nitrometer, Vycor combustion tubes and Vycor post heater tube, and other accessories;
- General laboratory glassware and hardware;
- Reagents for Coleman analyzer;
- Barometer.

4.6.1.6 Analysis of Waste Samples for Other Elements

It is suggested that after the samples have been prepared, any analysis for metals, etc., could be done at another laboratory by X-ray fluorescence, atomic absorption or scanning electron microprobe.

4.6.1.7 Analysis of Plant Emissions - Air

Sampling of air effluents is described in section 4.4 of this report, the treatment of samples thus obtained is considered in this section.

In the analysis of particulate emissions, a glass fibre filter, conditioned in a dessicator, is preweighed, then after the test reconditioned and reweighed. A balance accurate to 0.1 mg is required for these weighings. Anderson particle size analyzer plates are treated in the same way as the filters.

Nitrogen oxide and sulphur trioxide measurements require a colorimeter such as the Coleman model 129 Spectrophotometer. Sulphur dioxide can be measured by titration. Absorbed species such as halides can be measured using specific ion electrodes.

Elemental analysis of the solids on the filter or other absorbed species in the impinger sections of the sampling train should be sent out to specialist laboratories for analysis by atomic absorption or X-ray fluorescence.

Odour analysis should also be performed away from the plant in a special odour-free room such as that available at Ontario Research Foundation.

4.6.1.7 (Cont'd)

Major equipment items required for on-site analysis are:

- Coleman Spectrophotometer;
- Dessicator cabinet;
- Balance weighing to 0.1 mg accuracy;
- Laboratory glassware;
- Laboratory reagents.

4.6.1.8 Analysis of Plant Emissions - Water

4.6.1.8.1 BOD Determination - Dissolved Oxygen Analyzer Method

Basically, the BOD determination involves the determination of the dissolved oxygen (DO) content of the aqueous sample before and after an incubation period (usually five days at $20^{o}C$).

The oxygen demand of effluent water streams is exerted by three classes of materials: (a) organic carbon material present; (b) oxidizable nitrogen, e.g. NH_3, NO_2 and organic nitrogen; (c) certain chemical reducing compounds, e.g. ferrous iron, sulphide, sulphite which will react directly. The nitrification process is usually inhibited by pretreatment of the sample, and the immediate oxygen demand may be calculated or measured. The BOD determination is, therefore, chiefly used for the organic carbon present.

Since effluent waters may contain many variables that affect the conventional chemical methods for determining dissolved oxygen, the Dissolved Oxygen Analyzer method with a specially designed probe is preferred.

Equipment requirements:

- Dissolved Oxygen Analyzer, Weston and Stack or Yellow Springs or equivalent with probe and thermistor temperature compensaion and agitation assembly, e.g. Weston and Stack Model 300B, Model A30B probe, or Yellow Springs;
- Air incubator or water bath at $20^{o}C \pm 1^{o}C$;
- Analytical balance (also trip balance if available);
- Magnetic stirrer with Teflon-coated stirring bar;
- Miscellaneous laboratory glassware and reagents.

4.6.1.8.2 Chemical Oxygen Demand (COD)

During the process of composting, refuse is broken down into a humus-like material by micro-organisms. The oxidation products of this process are carbon dioxide, water and heat.

The extent of the biological oxidation with time may be followed by measuring the extent to which the refuse (compost) is oxidized by chemical means in the laboratory under certain conditions. This ability to be oxidized is called the chemical oxygen demand (COD).

4.6.1.8.2 (Cont'd)

Equipment required:

- Reflux apparatus -- consisting of 250 ml Erlemeyer flasks with reflux condenser, several of these would be required and a minimum of twelve sets is suggested;
- Hot plates (to produce at least 9 watts/square inch of heating surface) six units suggested;
- General glassware and reagents.

4.6.1.8.3 Ion Analysis

A specific ion analyzer will allow the analysis of many dissolved chemical species in water effluents. Included in this list would be cyanide, nitrate, fluoride, chloride, bromide, iodide, sulphide, sodium, potassium, copper, lead and calcium. Other analyses would have to be performed by atomic absorption.

Equipment required:

- Orion specific ion analyzer model 407;
- Twelve specific ion electrodes;
- Two reference electrodes.

4.6.1.9 Microbiological Laboratory

Proper design and safe procedures in a micro-biological laboratory are mandatory. Basically, all micro-organisms should be regarded as presenting some degree of hazard in one way or another. In practice, economic considerations all too often

dictate the need for, and extent of, precautionary measures. A happy medium can be struck only after due assessment of all available considerations. At the present stage, it is only possible to predict and consider some of the problems which may be encountered.

Three requirement areas for microbiological analysis in solid wastes handling involving public health and sanitation are envisaged:

(i) Methods for indicating the sanitary quality of solid waste before and after processing or disposal;

(ii) Methods for determining the efficacy of operational procedures for removing or destroying pathogenic organisms;

(iii) Methods for indicating the health hazard of solid waste in which pathogenic micro-organisms may be present in small numbers.

A bacteriological evaluation of solid waste, incinerator residue, compost, industrial and quench waters, leachates, stack emissions and dust, in and around the waste processing areas, will therefore in all probability be required on a regular basis.

4.6.1.9. (Cont'd)

The microbiological laboratory should be equipped to enumerate:

(i) Total number of viable bacterial cells in air, water, solids;

(ii) Total coliforms, faecal coliforms;

(iii) Heat resistant spores;

(iv) Enteric pathogens, e.g. Salmonella spp.

Equipment for Microbiological Laboratory:

- Steam (or electrically heated) autoclave, e.g. American Sterilizer, Castle, Barnstead or equivalent (electrically operated, 230 V, 50 amp service, or steam operated);
- Hot air oven (170^{o} - 250^{o}C), Gallenkamp, Blue M or or equivalent;
- Water bath "New Brunswick RW650" or equivalent;
- Quebec colony counter New Brunswick Model C110 or equivalent;
- Bacteriological incubator, Blue M or equivalent;
- Refrigerator/freezer - any domestic model suitable;
- Microscope Sterio Zoom Olympus Model SZ111 or equivalent;
- Microscope American Optical AO Series 10, phase contrast microscope or equivalent;
- "Bioguard" sterile hood or equivalent;
- Waring blender (two speed);
- Torsion balance (to 2 Kg);
- Membrane filter apparatus Millipore Corp. or equivalent (6-place);

- All glass impingers for air sampling (6);
- Vacuum/pressure pumps for 12 and 13 above (2);
- Vortex mixer (1);
- Culture media;
- General laboratory glassware.

The microbiological laboratory should be a self-contained separate closed area. Special services required are: steam for autoclave, gas for bunsen burners for flaming loops, etc. Bench tops should be seamless construction and a large wash-up sink should be in the area. An area of approximately 10 feet x 30 feet is recommended. A distilled or deionized water supply is mandatory.

4.6.2 Utilities Required

The following utilities will be required in the laboratory:

- 250 amp, 230/115 volt electrical service;
- Hot, cold and deionized water;
- Compressed air at 65 psi;
- Low pressure steam - 50 - 60 psi;
- Heating and air conditioning;
- Two large fume hoods with 1200 cfm extractor fans;
- Three telephone lines, one used with a time-sharing computer terminal console;
- Benches with cupboards and drawers;
- Two desks, chairs, bookcases, etc.

4.6.3 Laboratory Equipment Required for Product Acceptability Assessment

Previously described requirements are for general analysis of refuse. When final product streams are produced, these may require special tests to determine how acceptable these products would be to a final industrial user. Close co-operation with industry will be needed to define an "acceptable" product. Many product streams are planned for the plant eventually, but at the start, three main streams will be produced:

1. Shredded combustible refuse for fuel;
2. Ferrous metals;
3. Paper for recycle.

These three are considered below:

4.6.3.1 Shredded Fuel

Properties which are important in a shredded fuel product are:

- Heating value;
- Consistency of heating value;
- Particle size;
- Chemical analysis;
- Ash content;
- Moisture content.

All of the experimental requirements to measure these properties are described in section 4.6.1. Additional

tests should be set up, however, to determine how easily the product can be transported pneumatically. Since baling will probably be required for transportation of the product to a users site, the shredded refuse should be baled, then the bales broken and the test repeated. A simple test loop ending in a simulated burner nozzle would be sufficient to check this aspect of the shredded fuel product.

Burning tests with and without supplementary oil or gas fuel will also be needed, but this is a process test, not a laboratory experiment.

4.6.3.2 Ferrous Metals

Two types of contaminants will be a problem with ferrous metal products; general garbage (paper, food wastes, etc.) adhering to the magnetically separated fraction, and other metals mixed with, alloyed with, or coated on the steel.

Measuring the combustible fraction of a ferrous metal sample can be achieved using the method described in section 4.6.1.3.

Metals contamination can be measured using any of the standard methods for metal analysis. X-ray fluorescence, atomic absorption or electron microprobe. Again, it is suggested that this work be done elsewhere.

4.6.3.3 Paper for Recycle

It is suggested that evaluation of paper for recycle be made using a pilot scale pulper to determine how readily a stream can be repulped, how great a fraction of rejects is in the stream, and finally the quality of the product pulp. A sketch is shown in Figure 4.5, the scale envisaged here would be about a 25 pound batch process. The product pulp would be sent to a laboratory like Ontario Research Foundation for papermaking evaluation tests.

4.7 ORGANIZATION AND MANAGEMENT OF RESEARCH IN THE CENTRE

4.7.1 Organization

The proposed Reclamation Centre, as currently conceived, could have a number of potentially conflicting objectives. For example, though experimental, it should have the capability of recovering substantial quantities of re-usable raw materials. Also, concurrent long-term and short-term research objectives should be obtainable. The nature of municipal solid waste requires research on recycling to be carried out in a multi-disciplinary manner. The interests of provincial, federal and municipal governments, as well as industry and research, will have to be reconciled in the operation of this facility. The efficient operation of research will only be attained if attention is paid to these

potential conflicts. The following recommendations are suggested as an approach to organization:

(i) Both long-term and short-term research should be conducted concurrently and programs that are given priority should integrate these two interests as much as possible.

(ii) A multi-disciplinary approach should be taken to research planning and execution.

4.8 CAPITAL AND OPERATING COST ESTIMATE

This section attempts to explore the total of the research program excluding plant operation and instrumentation. It must be stressed that these are very rough estimates, but should be useful as a guide to costs of the operation.

4.8.1 Capital Costs

4.8.1.1 Laboratory Building

A generally accepted cost for laboratory space, including benches, utilities, etc., is $50.00 per square foot. The total laboratory area in Figure 4.2 is 1500 square feet, giving a total cost of $75,000.00.

4.8.1.2 Initial Equipment Costs

Equipment costs are totalled below. A total cost for the equipment described in the various foregoing sections is listed below with the section numbers in which the tests are described identifying each price.

Tests Described in Section	Equipment Cost
4.4.1	$ 20,000.00
4.4.2	5,000.00
4.6.1.1	15,000.00
4.6.1.2	4,000.00
4.6.1.3	2,500.00
4.6.1.4	3,000.00
4.6.1.5	4,000.00
4.6.1.6	-
4.6.1.7	5,000.00
4.6.1.8	9,000.00
4.6.1.9	19,000.00
4.6.2	(included in laboratory cost)
4.6.3.1	2,000.00
4.6.3.2	2,000.00
4.6.3.3	26,000.00
Miscellaneous	15,000.00
TOTAL	$131,500.00

An allowance of about $30,000.00 per year for additional equipment is suggested on top of the

annual cost of consumables such as reagents, gases, etc., which are considered as operating costs. This allowance will cover the cost of new equipment which will be required to perform tests on the products of the additional plant modules which will be built after the initial installation.

4.8.2 Annual Operating Costs

Costs are calculated for 1974, inflation at 8% per year would be applicable for subsequent years operation.

4.8.2.1 Research Personnel

Assuming that Ontario Research Foundation ran the research program, the costs involved would be based on one research scientist at normal O.R.F. overhead rates and a senior technologist and a technician at reduced overhead rates. This would recognize the fact that many O.R.F. services are not being used by the field men.

1974 Costs: $96,000.00

4.8.2.2 Computer Terminal Rental and Time-Sharing Costs

Costs of about $250.00 per month are applicable to time-sharing terminal rental. With storage and computer time, a total cost of $500.00 per month should be considered.

Annual Cost: $ 6,000.00

4.8.2.3 Utilities, Telephone, etc.

Based on the experience of O.R.F.'s Sarnia Laboratory, these costs would be of the order of $3,000.00.

4.8.2.4 Supplies

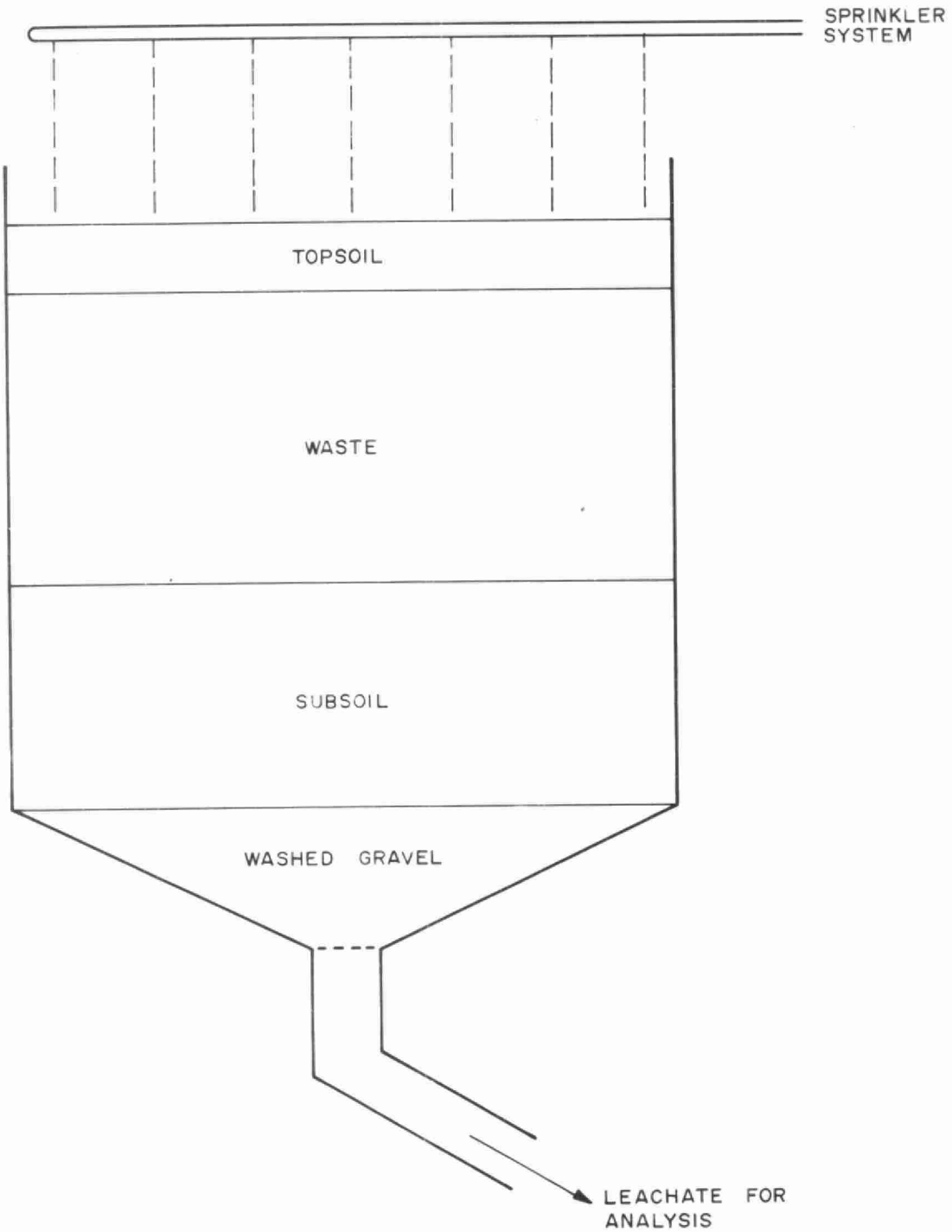
Consumable items such as bottled gases, reagents, glassware, etc., should not exceed an annual cost of $10,000.00.

4.8.2.5 Consultation and Contracted Out Analyses

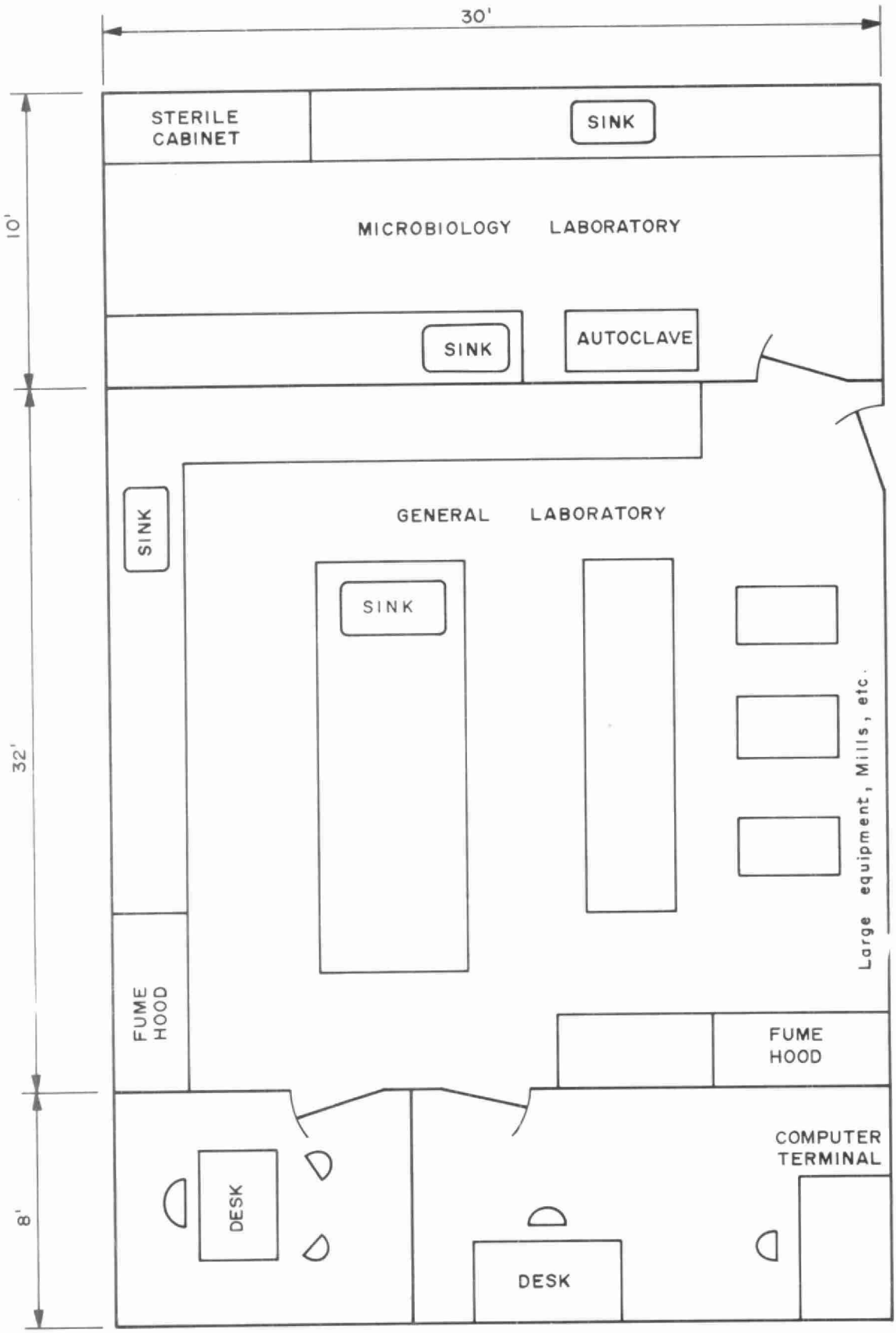
This is very difficult to estimate, since it is an undefined quantity. It could range from simple contracting out of metals analysis, to the support of small scale research programs aimed at basic improvements in secondary product purification. An allowance of $40,000.00 is suggested.

4.8.3 Total Annual Costs (1974 dollars)

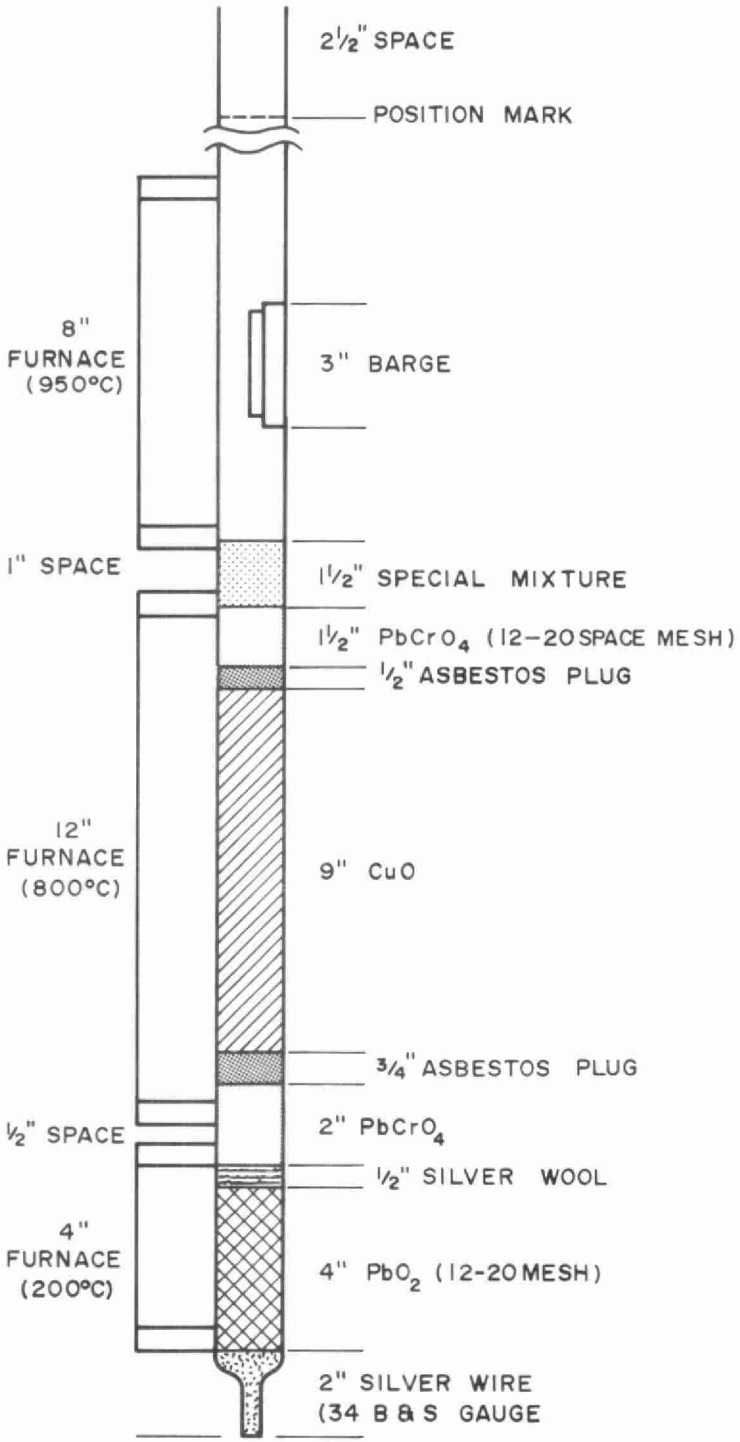
1.	Annual Equipment Allowance	$ 30,000.00
2.	Labour Cost	96,000.00
3.	Computer Cost	6,000.00
4.	Utilities, Telephone, etc.	3,000.00
5.	Materials, Supplies, etc.	10,000.00
6.	Consultation and Contracted Out Analyses	40,000.00
		$185,000.00



POSSIBLE LANDFILL TEST BED

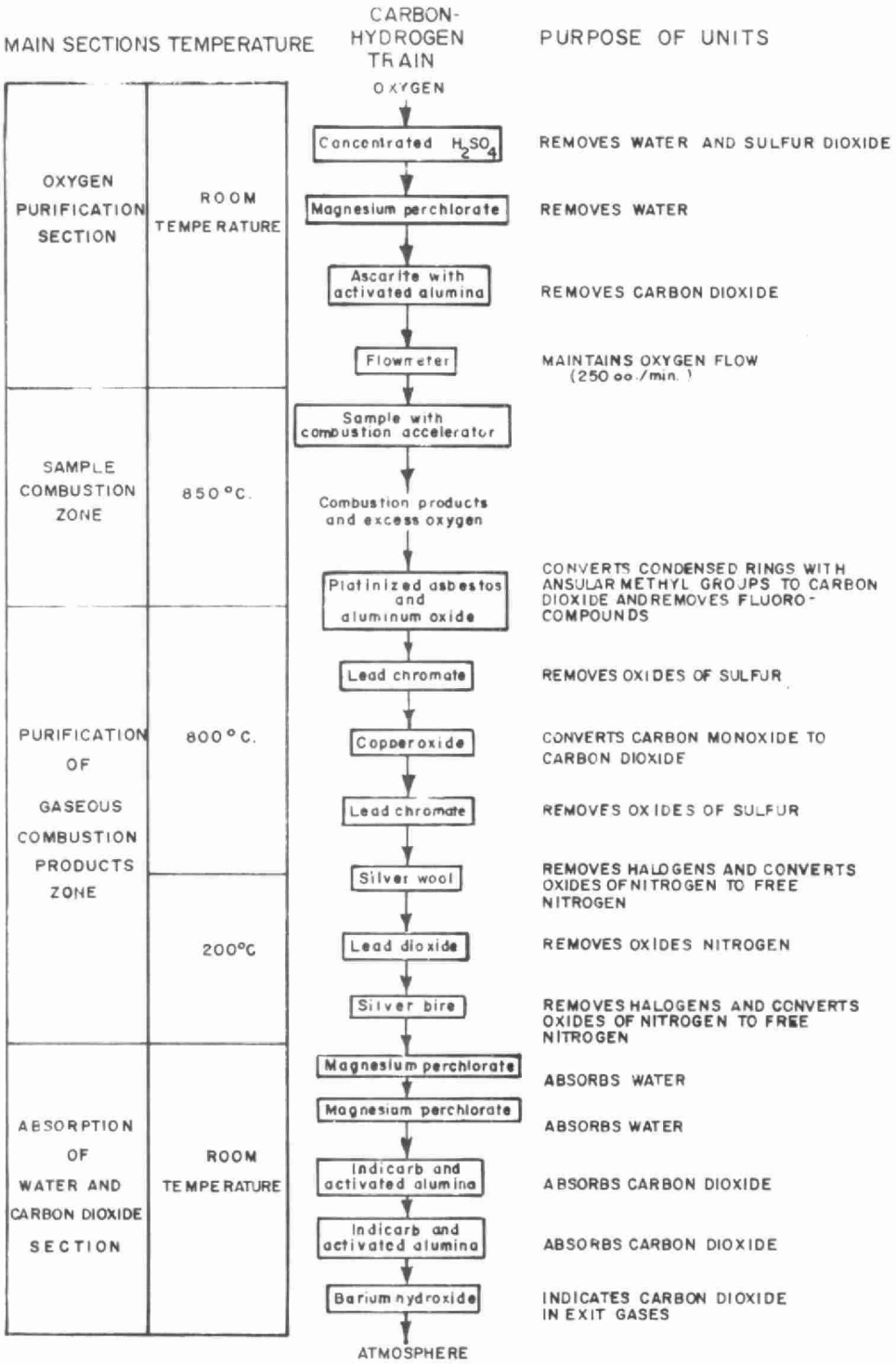


PROPOSED BASIC LABORATORY LAYOUT 4.2

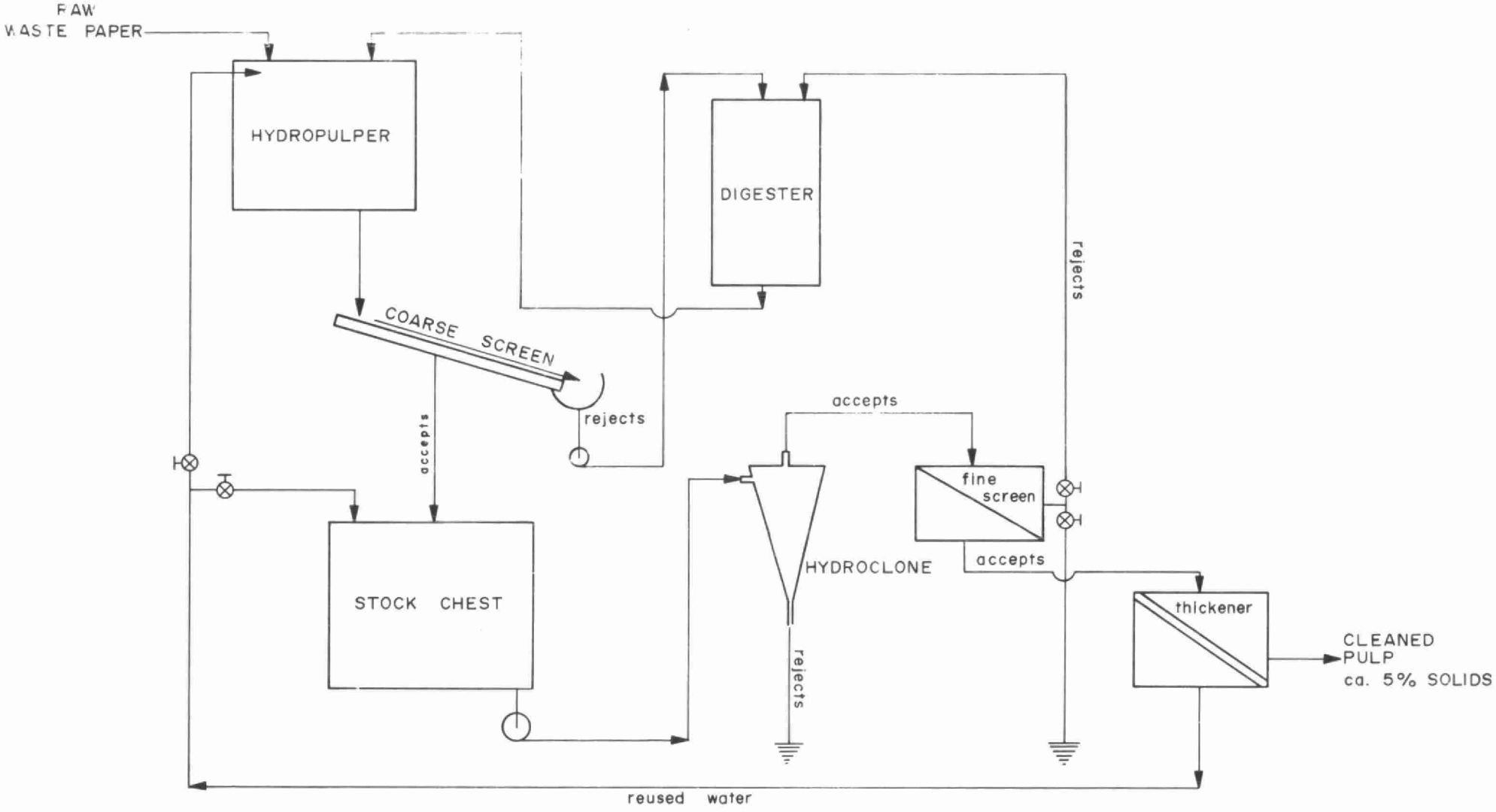


PACKED COMBUSTION TUBE

4.3



GENERAL OUTLINE OF CARBON-HYDROGEN TRAIN. 4.4



PILOT SCALE PAPER FIBRE SEPARATION PLANT

4.5

982-130-6

ENTRANCE
PACKER
SHIPPING
REFUSE
REFUSE RECEIVING ELEV. +20
WHITE GOODS ETC.
PAPER
INSPECTION & MANUAL SEPARATION STATION
VIBRATING TABLE
SHREDDER ELEV. 0'
ELEV. -16'
REJECTS CONTAINER
NEWSPRINT SURGE
CORRUGATED SURGE
BALER
EXIT
ELEV. -3.5'
SHIPPING DOCK
BALE STORAGE ELEV. 0'
BLOWER
CYCLONE SEPARATOR
CLASSIFIER
ELEV. 0'
ROTARY SCREEN
SHIPPING
IN PLANT HEATING UNIT ENERGY CONVERSION
MOVABLE MANUAL SEPARATION STATIONS ▼ TOTE BOXES
ROTARY SCREEN
OVERSIZED
FINES
LIGHTS
HEAVIES
GRAVITY TABLE
NON- FERROUS METALS EXTRACTION
MAGNETIC SEPARATOR
FUTURE TEXTILE MATERIAL EXTRACTION & PREPARATION
METAL BALER
FUTURE METALS THERMAL PROCESS
LOADING DOCK ELEV. +4'
3-WAY DIVERTER FOR TRUCK TO LANDFILL or CONVEYOR TO COMPOSTING (SEE INSERT)
AGGREGATE STORAGE
RAMP
SAMPLING LOCATION
WEIGHT MONITORING

PLAN VIEW

DIGESTER
SHUTTLE CONVEYOR
STORAGE
TRUCK LOADING

COMPOSTING - STORAGE & SHIPPING

INSERT

DWG. NO.	REFERENCE DRAWINGS	NO.	DESCRIPTION	DATE	BY
			REVISIONS		

SECTION:
SCALE: 1/16" = 1'-0" DATE
DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY: H.W. FEB 25/76

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO CANADA

KILBORN

TITLE
200 T/D EXPERIMENTAL SOLID WASTE RECLAMATION PLANT
MONITORING LOCATIONS

ACCT. No.	
PROJECT No.	DIVISION No.
982	15
DRAWING NUMBER	
982-130-6	REV.

S E C T I O N 5

EQUIPMENT

EQUIPMENT

5.1 GENERAL

All of the equipment listed, with the exception of item 17 - Stratifibre Classifier and the boilers of the energy conversion unit, are commercial items that have been in general use in the resource recovery industry and in the waste industry for a considerable number of years. This will allow the basic plant to function with a high degree of reliability and predictability.

5.2 AVAILABILITY OF EQUIPMENT

Under normal economic conditions, most of the equipment used is readily available with deliveries running approximately 10 to 12 weeks. However, a few items will be as long as 9 months delivery.

5.3 DEVELOPMENT EQUIPMENT

Two items listed which are umproven pieces of equipment are item 17 - Stratifibre classifier, and a small boiler in the energy conversion unit.

The reason for suggesting this particular classifier is because of the unsatisfactory separation effected by the majority of commercially available units as experienced at installations such as Union Electric.

Since the utilization of the combustible fraction of solid waste in small boiler units has been identified

5.3 (Cont'd)

as a high priority research project, it was thought desirable to include the most promising development of this type in the original plant. Funds have been included for purchasing these items, but since the manufacturers consider them proprietary, it may be possible to obtain these at nominal sums for testing.

5.4 SIZING OF EQUIPMENT

The plant has generally been sized to handle 200 tons of solid waste in 8 hours. In-feed conveyors have considerably higher capacity, being able to handle up to 500 tons in 8 hours. There are two reasons for this:

1. The necessity of being able to load the shredder for developing shredding costs versus loading.

2. The physical limitations posed by the ability of a conveyor to be used as a storage bin to avoid floor storage during surges of packer delivery.

5.4.1 Primary Shredder

The size of this item is determined by the maximum size of material that will be fed to it and not by its capacity. The size of shredder shown is the absolute minimum recommended if the necessary

versatility and flexibility of the experimental plant is to be retained.

The rest of the plant is sized to handle the 200 tons of solid waste or any fraction of it in 8 hours.

5.5 EQUIPMENT LIST

Numbers correspond to item numbers on Drawings.		Account Code No.
1.	12' x 65' White goods receiving apron conveyor	212-110
2.	12' x 70' Refuse receiving apron conveyor	212-120
3.	12' x 30' Compactor conveyor	212-130
4.	Surge bin	212-140
5.	Compactors - 3 @ 10,000 each	212-150
6.	6' x 70' Corrugated paper belt	212-180
7.	5' x 105' Vibrating conveyor	212-190
8.	Manual separation station	212-200
9.	Newsprint surge belt conveyor 3' x 55'	212-210
10.	Corrugated surge belt conveyor 6' x 55'	212-220
11.	Baler	212-230
12.	Shredder receiving hood	222-110
13.	Shredder - w/1000 HP motor	222-120
14.	Shredder - discharge hopper	222-130
15.	6' x 15' Vibrating conveyor	222-140
16.	4' x 210' Classifier feed belt	252-110
17.	Strati fibre classifier	232-110
18.	6' x 18' Heavies discharge conveyor	232-120

5.5 (Cont'd)

		Account Code No.
19.	Blower	232-130
20.	Cyclone separator	232-140
21.	Rotary screen - paper	232-150
22.	Blower	232-160
23.	Cyclone separator	312-110
24.	Fibre fuel storage w/conveyor	312-120
25.	2' x 25' Screen tailings discharge belt conveyor	232-170
26.	4' x 75' Classifier heavies belt conveyor	252-120
27.	Magnetic separator	262-120
28.	3' x 50' Ferrous discharge belt	262-130
29.	Ferrous surge hopper	262-140
30.	Metal baler	262-150
31.	4' x 90' Non-Ferrous discharge belt	262-160
32.	Movable manual separation stations	262-170
33.	4' x 40' Screen feed belt	262-180
34.	Rotary Screen	262-190
35.	2' x 35' Oversize belt	262-200
36.	2' x 110' Oversize conveyor	262-110
37.	3-Way Diverter	262-210
38.	2' x 35' Screen fines belt	262-220
39.	Gravity table	262-230
40.	2' x 90' Heavy belt conveyor	262-240
41.	Storage bin	262-250

		Account Code No.
42.	2' x 45' Lights belt conveyor	262-260
43.	2' x 400' Composting belt conveyor	262-270
44.	2' x 18' Distribution conveyor	412-110
45/46.	15' x 18' Agitator & out-loader	412-120
47.	16' x 160' x 6' Digester	412-130
48.	Blank	
49.	2' x 25' Transfer belt conveyor	412-140
50.	2' x 105' Storage conveyor	412-150
51.	2' x 100' Shuttle conveyor	412-160
52.	Energy conversion unit	312-150
53.	Dust collectors	312-140
-	Baghouse	312-180
-	Laboratory equipment	202-110
-	Truck scales	202-120

S E C T I O N 6

FLOWSHEETS AND CONCEPTUAL PLANS

PRELIMINARY FLOWSHEET AND CONCEPTUAL LAYOUT

6.1 GENERAL

The governing concept of the basic design has been to conceive a long-term research facility capable of generating the economic information, the technology, and the incentive to provide guidance for the building of Solid Waste Reclamation plants as an alternative to present methods of disposal.

The flowsheet (Drawing No. 982-130-7) for the primary separation plant is based on known technology and on the experience gained from existing Solid Waste operations.

It also incorporates (Drawing No. 982-130-8) technology and principles developed for the resource recovery industries and industrial processes.

The conceptual plant layouts (Drawing Nos. 982-130-1 to 5) show where plant modules of known and developing technology can be added to the facility for appraisal. All operational and environmental data will be brought to a central location for monitoring and control to enable a complete evaluation to be made on both the primary and secondary processing modules.

A double manual inspection station allows clean corrugated cardboard to be recovered and baled and

6.1 (Cont'd)

also to prevent the possible entry of materials that could damage the plant (gasoline, explosives, propane). Primary size reduction only is carried out at this location, leaving secondary size reduction to be optimized at each of the secondary modules as necessary.

6.2 PLANT DESCRIPTION BY AREA IS AS FOLLOWS:

6.2.1 Area 211 - Receiving and Paper Recovery

Packer trucks are guided to specific dump points by red and green lights controlled by the height of the material at selected locations. The recessed apron conveyors act as storage bins and have capacity for four hours operation or 100 tons. Trucks dump directly onto the apron conveyors. There are no columns in the building which also has sufficient height to allow the various types of packers to dump completely.

Provision has been made to accept white goods (refrigerators, washing machines) bedsprings, etc. Provision has also been made to accept and directly bale source separated material such as bundled newspapers and corrugated cardboard.

Variable speed control of the apron conveyors controls the feed rate to the vibrating feeder which then controls the feed rate to the size reduction unit.

This area also contains a surge bin and compactor should it be necessary to transfer the material directly to a tractor trailer for transportation to a landfill site and as such could be used as a Transfer Station.

6.2.2 Area 221 - Shredder Building

The size reduction unit has been located in a separate building to allow proper noise control to be exercised and also for safety against fires and explosives. A dust collection system on the unit assists in keeping the inside of the building at a reasonable level of cleanliness. A vibrating feeder moves the shredded material onto a belt conveyor feeding the air classifier.

6.2.3 Area 231 - Air Classifier Building

The air classifier building contains an air classifier which can be any one of several types, cyclones, blowers and baghouses to enable the air to be used for classification, drying and transportation of the material. Classifying and transportation has been split into two functions to avoid having air quantities and air velocities interdependent. A Rotary Screen separates dust and inerts from the combustable fraction.

The heavies collected from the air separation unit are transported by belt conveyor to the metal reclamation centre.

6.2.4 Area 261 - Metal Reclamation Centre

Ferrous metals are picked off the belt conveyor by a belt magnet and deposited onto a second belt conveyor for transport to a surge bin and metal baler. At this point a secondary shredding operation could be introduced in place of the metal baler depending on the end use and the specific tests to be run.

The balance of the material, the non-ferrous metals and heavies, are screened in a rotary screen which removes the glass and inerts. Oversize is carried to a wet elutriator for density classification. Here, the non-ferrous metals sink to the bottom and are removed, aluminum and plastics are removed midway on the column, and vegetable and food wastes being discharged at the top. Sloped screens remove pulp and fines leaving clean plastic and aluminum on one and larger food and plant waste on the other.

The water treatment cycle is located in the composting section becoming part of this operation.

If this fraction is to be landfilled in the initial stages, the wet elutriation section would not be installed.

6.3 SECONDARY PROCESSING MODULES

There is a choice of several secondary processing modules in which technology is quite advanced and

which could be utilized to generate revenue to defray operating costs.

These are:

(a) Energy Conversion Module (direct fired)

(b) Composting Plant

(c) Fibre Recovery Plant

(d) Incinerated Residue Recovery Module

(e) Plastics Recovery Module

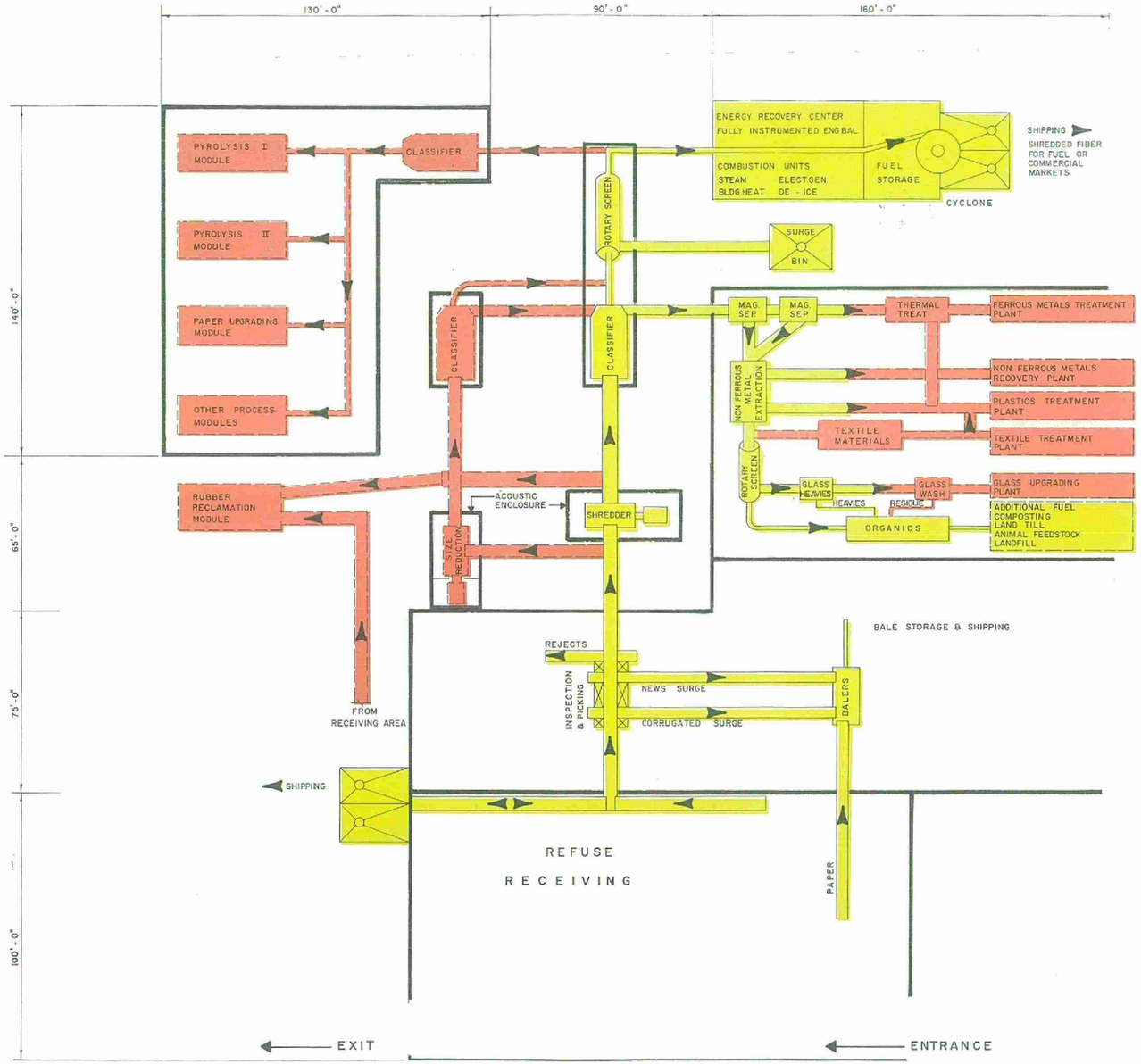
Since all communities, large and small, will eventually be faced with the problems of solid waste disposal and sewage sludge disposal, it appears that the modules offering solutions to these two problems would be the most beneficial.

Consequently, we have shown both an energy conversion module and a composting module as part of the original concept.

The composting module shown is representative of the several commercial types available for accelerated aerobic digestion by mechanical means and is indicative of the space requirement and cost.

The conceptual layout allows sufficient space for any type of composting, ranging from windrowing to complete aerobic digestion by means of air.

982-130-7



LEGEND:

- INITIAL INSTALLATION
- FUTURE PROBABLE INSTALLATION
- PROBABLE BUILDINGS

EXPERIMENTAL WASTE RECLAMATION PLANT.

- DO NOT SCALE ALL DIMENSIONS APPROX. -

THIS DRAWING WAS PREPARED BY KILBORN ENGINEERING LTD. FOR THE EXPERIMENTAL WASTE RECLAMATION PLANT OF THE MINISTRY OF THE ENVIRONMENT, WASTE MANAGEMENT BRANCH AND MAY NOT BE USED FOR ANY OTHER PROJECT EXCEPT WITH PERMISSION IN WRITING FROM KILBORN ENGINEERING LTD.

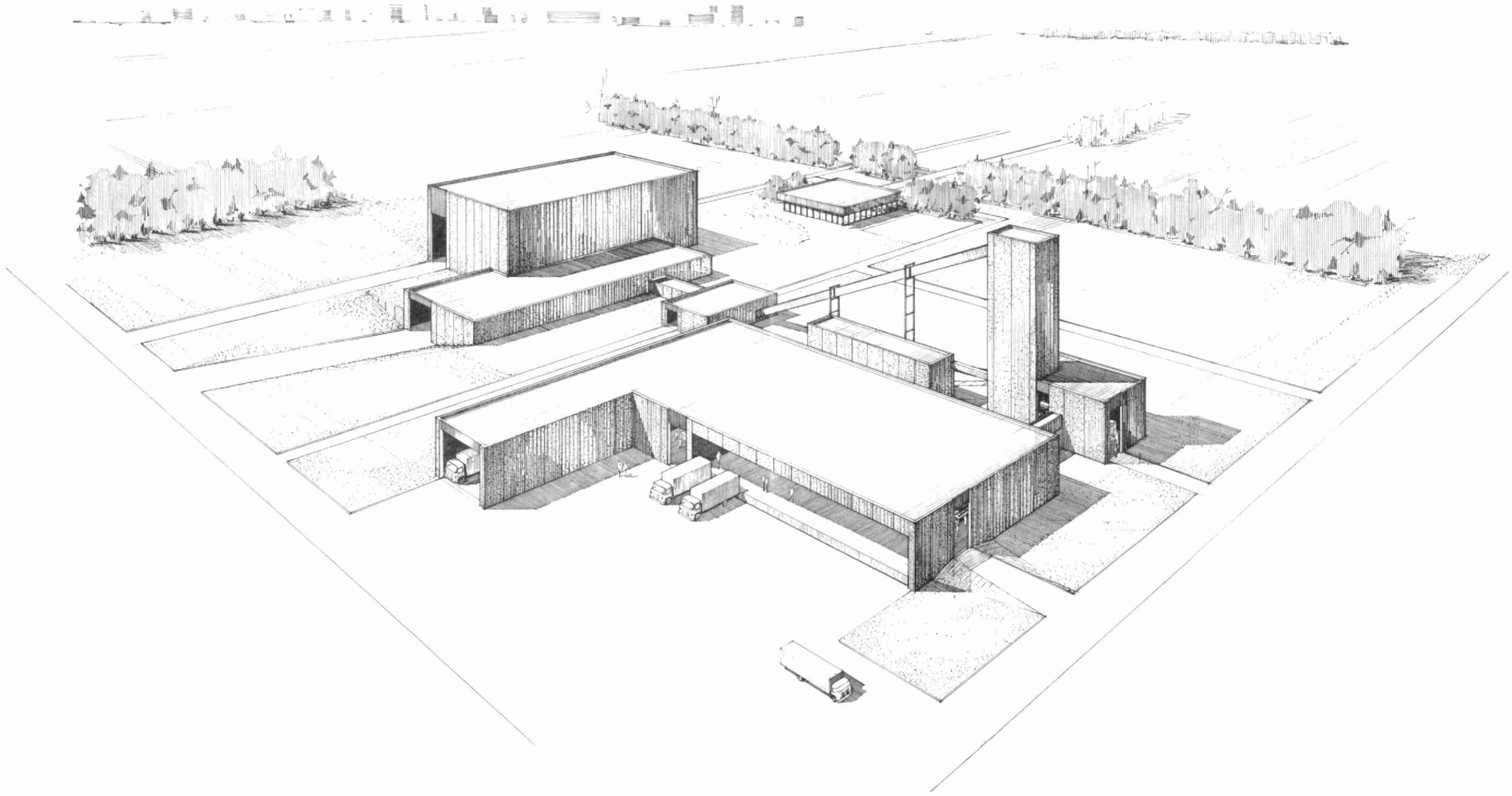
DWG. No. | REFERENCE DRAWINGS | No. | DESCRIPTION | DATE | BY — REVISIONS

SECTION: | SCALE: N.T.S | DATE | DESIGNED BY: | DRAWN BY: | CHECKED BY: | APPROVED BY:

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO . CANADA.
KILBORN — KILBORN ENGINEERING LTD., THORNCLIFFE PARK DRIVE, TORONTO ONT., CANADA, M4H 1J1 TELEX: 06-22769

TITLE: 200 T/D EXPERIMENTAL SOLID WASTE RECLAMATION PLANT. MODULE CONCEPT.

ACCT. No. | PROJECT No. 982 | DIVISION No. 15 | DRAWING NUMBER 982-130-7 | REV.



DWG. No. | REFERENCE DRAWINGS

CLIENT | PROJ. ENG. | CO-ORDIN. | CIVIL | ELECTR. | MECH. | P.P. | ARCH. | CHEM. | STEEL | BRIDGES | MPAL | GEN. LAB.

NO. | DESCRIPTION | DATE | BY

REVISIONS

SECTION: ARCHITECTURAL

SCALE: | DATE

DESIGNED BY: H. SCHMEL.

DRAWN BY: E.C. / K.H. | FEB. '74

CHECKED BY:

APPROVED BY:

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT

LOCATION: TORONTO, ONTARIO.

KILBORN — KILBORN ENGINEERING LTD. TORONTO-DOMINION CENTRE, P.O. BOX 88, TORONTO, ONT., CANADA M5K 1B9

TITLE

200 T.P.D. EXPERIMENTAL SOLID WASTE, RECLAMATION PLANT

PRELIMINARY ARCHITECTURAL

PROJECT No. 282 | DIVISION No. 15

DRAWING NUMBER

REV.

982-130-1

ENTRANCE
PACKER
SHIPPING
REFUSE
REFUSE RECEIVING ELEV. +20
WHITE GOODS ETC.
INSPECTION & MANUAL SEPARATION STATION
VIBRATING TABLE
REJECTS CONTAINER
SHREDDER ELEV. 0'
ELEV. -16'
PAPER
BALER
CORRUGATED SURGE
NEWSPRINT SURGE
ELEV-35'
BALE STORAGE ELEV. 0'
SHIPPING DOCK
EXIT
BLOWER
CYCLONE SEPARATOR
CLASSIFIER
ELEV. 0'
ROTARY SCREEN
IN PLANT HEATING UNIT ENERGY CONVERSION
MOVABLE MANUAL SEPARATION STATIONS W TOTE BOXES
ROTARY SCREEN
MAGNETIC SEPARATOR
OVERSIZED
FINES
NON- FERROUS METALS EXTRACTION
LIGHTS
GRAVITY TABLE
HEAVIES
FUTURE TEXTILE MATERIAL EXTRACTION & PREPARATION
METAL BALER
FUTURE METALS THERMAL PROCESS
3-WAY DIVERTER FOR TRUCK TO LANDFILL or CONVEYOR TO COMPOSTING (SEE INSERT)
AGGREGATE STORAGE
LOADING DOCK ELEV +4'
RAMP

PLAN VIEW

DIGESTER
SHUTTLE CONVEYOR
STORAGE
TRUCK LOADING

COMPOSTING - STORAGE & SHIPPING

INSERT

DWG. NO.	REFERENCE DRAWINGS

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

SECTION
SCALE: 1/16" = 1'FT
DESIGNED BY
DRAWN BY
CHECKED BY
APPROVED BY: H.W. FEB 25/76

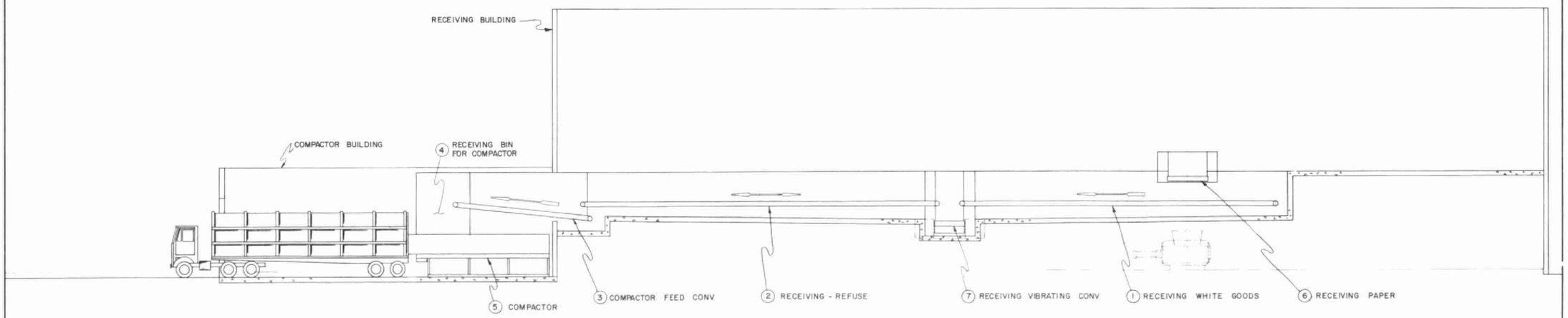
CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO CANADA

KILBORN KILBORN ENGINEERING LTD. TORONTO, ONT., CANADA

TITLE
200 T/D EXPERIMENTAL SOLID WASTE RECLAMATION PLANT
PRIMARY MODULE
PRELIMINARY PLANT LAYOUT

ACCT. No.
PROJECT No. 982
DIVISION No. 15
DRAWING NUMBER
982 - 130-1
REV.

DRAWING No. 982-130-2



SECTION A-A

DWG. NO. | REFERENCE DRAWINGS

REVISIONS | NO. | DESCRIPTION | DATE | BY

SECTION | SCALE N.T.S. | DATE | DESIGNED BY | DRAWN BY | CHECKED BY | APPROVED BY H.W. FEB 25/76

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT

LOCATION: TORONTO, CANADA

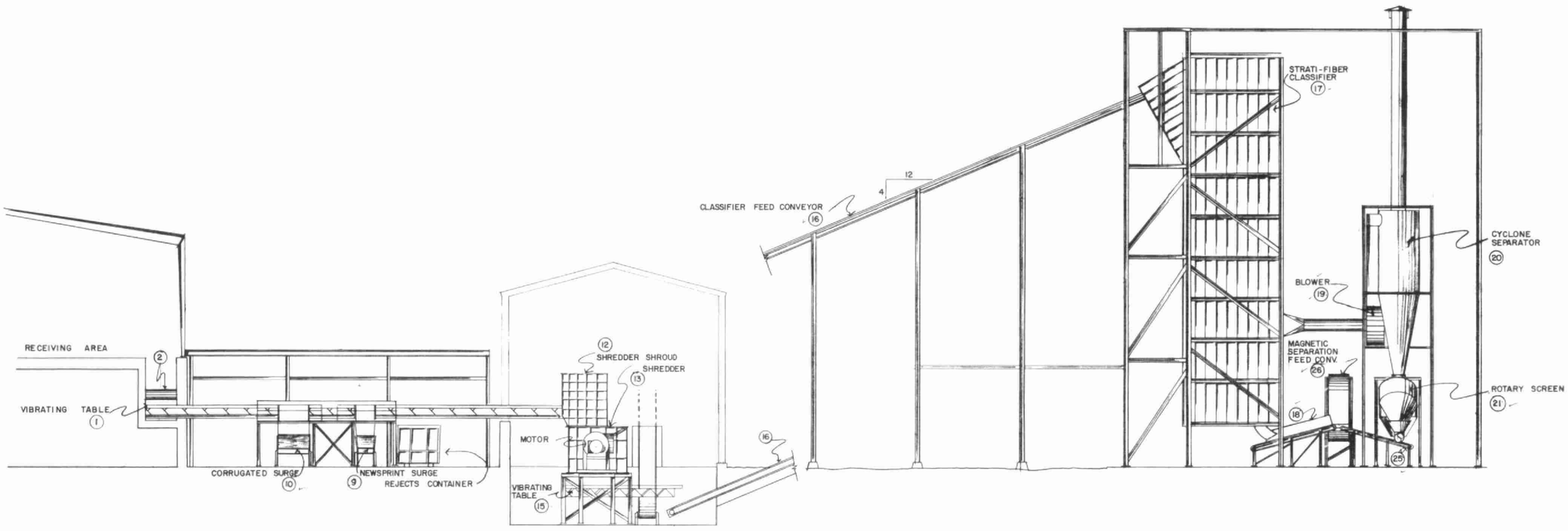
KILBORN

TITLE: 200 T/D. EXPERIMENTAL SOLID WASTE RECLAMATION PLANT PRIMARY MODULE SECTION A-A

ACCT. No. | PROJECT No. 982 | DIVISION No. 15

DRAWING NUMBER 982-130-2 | REV.

DRAWING No. 982-130-3



SECTION B-B

DWG NO.	REFERENCE DRAWINGS	REVISIONS	DATE	BY

SECTION:
SCALE: N T S — DATE
DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY: H.W — FEB 25/74

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO CANADA

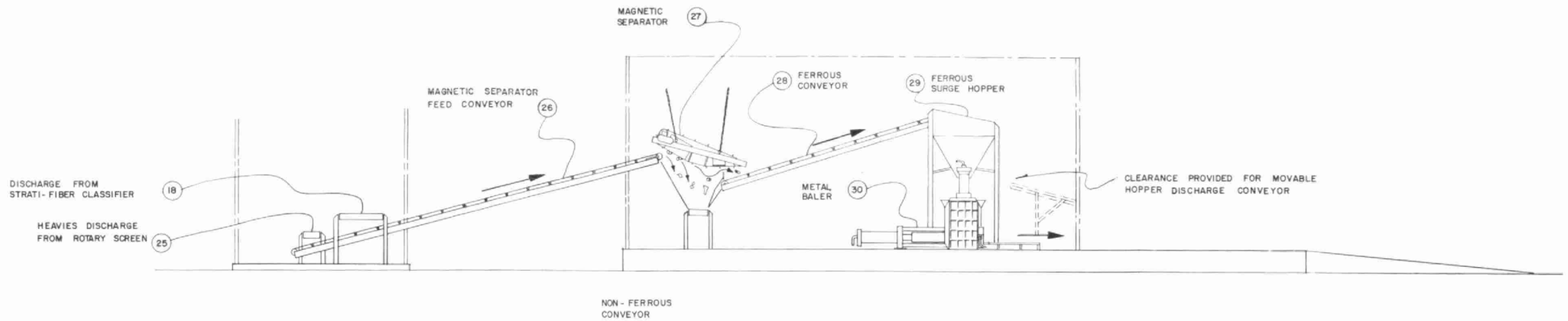
KILBORN — KILBORN ENGINEERING LTD., TORONTO, PARK LANE CIR., TORONTO, ONT., CANADA, 416, 366-7161, TELEX: 06-23781

TITLE
200T/D EXPERIMENTAL SOLID WASTE RECLAMATION PLANT PRIMARY MODULE
SECTION B-B.

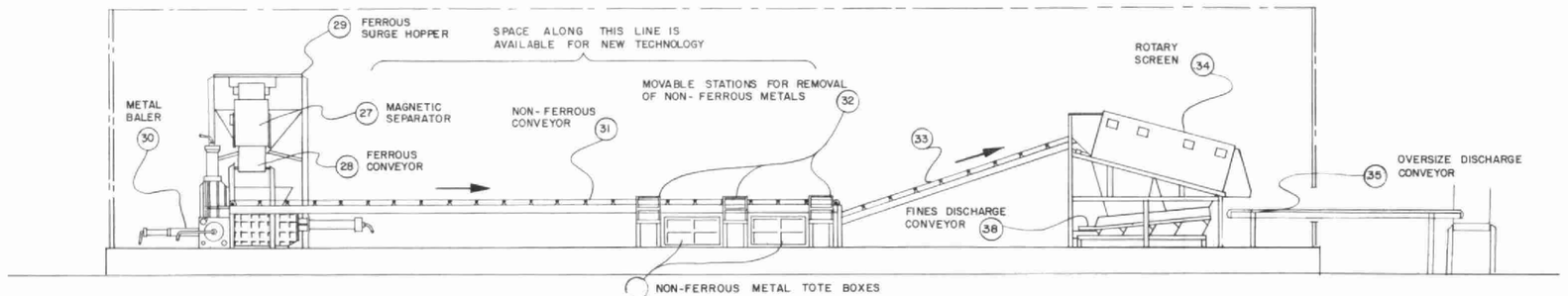
PROJECT No.	DIVISION No.
982	15

DRAWING NUMBER
982-130-3

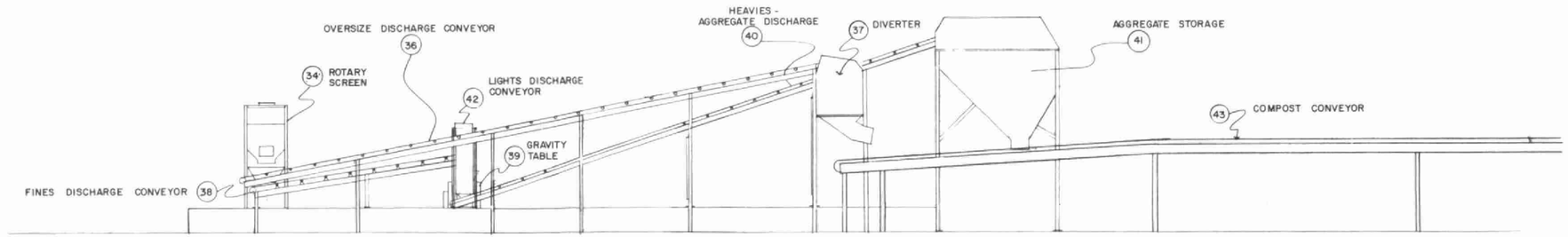
982-130-4



SECTION C-C — FERROUS EXTRACTION LINE



SECTION D-D — NON-FERROUS METALS EXTRACTION & SIZE SEPARATION LINE



SECTION E-E — TRANSFER STATION WITH GRAVITY TABLE & AGGREGATE STORAGE IN BACKGROUND

DWG NO. | REFERENCE DRAWINGS | REVISIONS | DESCRIPTION | DATE | BY

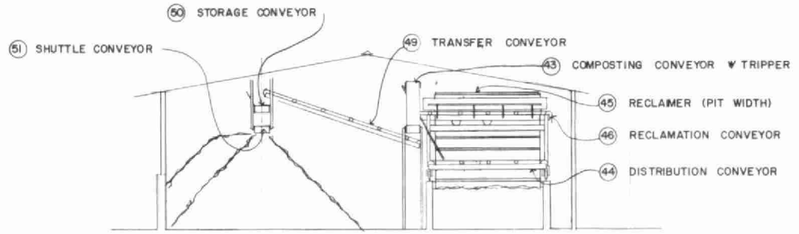
SECTION: | SCALE: N.T.S. | DESIGNED BY: | DRAWN BY: | CHECKED BY: | APPROVED BY: H.W. FEB 25/76

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO, CANADA
KILBORN

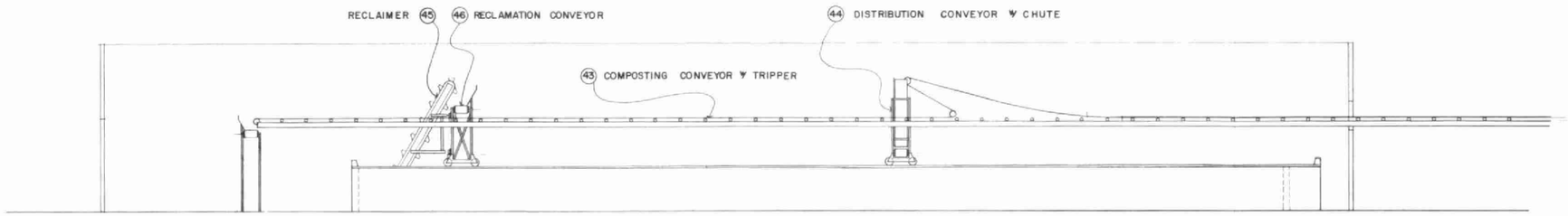
TITLE
200 T/D. EXPERIMENTAL SOLID WASTE RECLAMATION PRIMARY MODULE SECTIONS C-C. D-D. E-E.

AGCT. No.
PROJECT No. 982 | DIVISION No. 15
DRAWING NUMBER 982-130-4 | REV

982-130-5



SECTION H-H — COMPOSTING



SECTION K-K — COMPOSTING BUILDING

DIGESTER BIN

DWG. NO. | REFERENCE DRAWINGS

REVISIONS

NO.	DESCRIPTION	DATE	BY

SECTION:
SCALE: N T S DATE
DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY: H W FEB 25/76

CLIENT: ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO, CANADA.

KILBORN KILBORN ENGINEERING LTD., TORONTO AND OTTAWA, ONT., CANADA AND MONTREAL, QUE.

TITLE
200 T D. EXPERIMENTAL
SOLID WASTE RECLAMATION PLANT
PRIMARY MODULE
SECTIONS H-H. K-K.

ACCT. No.	
PROJECT No.	DIVISION No.
982	15
DRAWING NUMBER	
982-130-5	REV.

1-01-001

TRUCK SCALES #212-240

WHITE GOODS

REFUSE

APRON FEEDER #212-120

APRON FEEDER #212-110

VIB. CONV. #212-130

SURGE BIN #212-140

CONV. #212-150

REJECTS BIN

COMPACTOR #212-150

ALTERNATE - TO LANDFILL

MANUAL SEPARATION STATION #212-200

SHREDDER HOOD #222-110

SHREDDER #222-120

VIB. CONV. #212-140

VIB. CONV. #212-160

FUTURE CONV.

	%	TPD
PAPER & CARDBOARD	39.00	390
FOOD WASTE	10.00	30
VEGETATION	10.00	14
PLASTICS & RUBBER	3.00	6
LEATHER	1.00	1.2
RAGS & TEXTILES	2.00	5.2
WOOD & MISC.	3.00	6.4
GLASS & CERAMICS	2.00	4.8
FERROUS METALS	5.00	13
NON-FERROUS METALS	1.00	1.8
INERTS	2.00	4.6
TOTAL	100.00	240

	%	TPD
CARDBOARD	3	6

	%	TPD
NEWSPRINT	3	6

	%	TPD
PAPER & CARDBOARD	64	890
FOOD WASTE	15	150
VEGETATION	7	14
PLASTICS & RUBBER	9	16
LEATHER	.6	1.2
RAGS & TEXTILES	2.6	5.2
WOOD & MISC.	3.2	6.4
GLASS & CERAMICS	6.4	16.8
FERROUS METALS	6.5	13
NON-FERROUS METALS	1.55	3.0
INERTS	2.3	4.6
TOTAL	96	1200

	%	TPD
PAPER	40	80
FOOD WASTE	48	96
VEGETATION	5	6
LEATHER, PLASTICS & RUBBER	2.0	4
WOOD & MISC.	2.2	4.8
GLASS & CERAMICS	1.4	4.8
NON-FERROUS METALS	.4	1.8
INERTS	.1	.4
TOTAL	85	192

	%	TPD
PAPER	40	80
FOOD WASTE	48	96
VEGETATION	5.0	6.0
PLASTICS & RUBBER	2.5	5.0
WOOD & MISC.	2.2	4.8
NON-FERROUS METALS	1.4	2.8
INERTS	.9	1.8
TOTAL	100	204

ROTARY SCREEN #262-190

CONV. #262-290

CONV. #262-200

ELUTRIATOR #262-210

SCREEN #262-270

SCREEN #262-280

CONV. #262-110

CONV. #262-260

CONV. 262-270

NON-FERROUS METALS STORAGE BIN

	%	TPD
PLASTICS & RUBBER	2.5	5.0
ALUMINUM	.7	1.4
TOTAL	3.2	6.4

	%	TPD
PAPER	40	80
FOOD WASTE	48	96
VEGETATION	5.0	6.0
WOOD	2.2	4.8
TOTAL	96	192

	%	TPD
NON-FERROUS METALS	.7	1.4
INERTS	.2	.4
TOTAL	.9	1.8

	%	TPD
GLASS	74	148
INERTS	10.5	21.0
TOTAL	84.5	169

GRAVITY TABLE #262-230

GLASS STORAGE BIN #262-250

	%	TPD
GLASS	74.0	148
INERTS	10.5	21.0
TOTAL	84.5	169

STRIPPER CONV. #411-110

COMPOST DIGESTER #411-130

ASTATIC LOADER #411-120

CONV. #411-140

CONV. #411-150

SHUTTLE CONV. #411-160

COMPOST STORAGE

TO ATMOSPHERE

EXHAUST FAN #232-130

BAG HOUSE #232-110

	%	TPD
PAPER	10	20
GLASS	10	20
INERTS	1.0	2.0
TOTAL	30	60

CONV. #232-110

AIR CLASSIFIER #232-120

EXHAUST FAN #232-160

BAG HOUSE #232-110

	%	TPD
PAPER	39	78
VEGETATION	4	8
PLASTICS	10	20
RAGS & TEXTILES	2.6	5.2
WOOD & MISC.	1.0	2.0
GLASS & CERAMICS	1.0	2.0
NON-FERROUS METALS	.1	.2
INERTS	.2	.4
TOTAL	48.9	97.8

CYCLONE #232-140

	%	TPD
PAPER	39	78
VEGETATION	4	8
PLASTICS	10	20
RAGS & TEXTILES	2.6	5.2
WOOD & MISC.	1.0	2.0
GLASS & CERAMICS	1.0	2.0
NON-FERROUS METALS	.1	.2
INERTS	.2	.4
TOTAL	48.9	97.8

	%	TPD
GLASS	10	20
INERTS	2	4
TOTAL	12	24

ROTARY SCREEN #232-150

BLOWER #232-200

	%	TPD
PAPER	4	8
FOOD WASTE	15	30
VEGETATION	3	6
PLASTICS & RUBBER	2	0
LEATHER	.6	1.2
WOOD & MISC.	2.2	4.4
GLASS & CERAMICS	6.4	12.8
FERROUS METALS	6.5	13
NON-FERROUS METALS	1.8	3.6
INERTS	1.0	2.0
TOTAL	41.1	82.2

CONV. #232-120

CONV. #232-170

CYCLONE #312-110

	%	TPD
PAPER	39	78
VEGETATION	4	8
PLASTICS	10	20
RAGS & TEXTILES	2.6	5.2
WOOD & MISC.	1.0	2.0
NON-FERROUS METALS	.1	.2
TOTAL	48.9	97.8

FIBRE STORAGE #312-120

	%	TPD
PLASTICS	1	2
FOOD WASTE	8	16
FERROUS METALS	6	12
TOTAL	6.5	13.0

SURGE HOPPER #262-180

METAL BALER #262-150

FORK LIFT

FERROUS BALED STORAGE

MAGNETIC SEPARATOR #262-120

CONV. #262-150

CONV. #262-180

TO ATMOSPHERE

EXHAUST FAN #312-150

BAG HOUSE #312-130

DUST COLLECTOR #312-140

ENERGY CONVERSION UNIT #312-150

COMPACTOR #312-160

COMPACTOR #312-170

TRUCK SCALES #212-240

CONV #212-180

PAPER BALER #212-230

CONV. #212-210

CONV. #212-210

DWG. No.	REFERENCE DRAWINGS

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

NO.	DESCRIPTION	DATE	BY
0	ORIGINAL	MAR 5/76	
	REVISIONS		

SECTION: GENERAL LAYOUT
SCALE: NONE
DESIGNED BY:
DRAWN BY: K. HASEN MAR 5/76
CHECKED BY:
APPROVED BY:

CLIENT: WASTE MANAGEMENT BRANCH MOE
LOCATION: TORONTO, ONTARIO

KILBORN
KILBORN ENGINEERING LTD. TORONTO 625 FARLEY BLVD. TORONTO ONTARIO, CANADA M1B 2K7 TELEX: 06-22746

TITLE
200 T.P.D. EXPERIMENTAL SOLID WASTE RECLAMATION PLANT
FLOW SHEET

ACCT. No.	
PROJECT No.	DIVISION No.
756	15
DRAWING NUMBER	
100-10F-1	REV. 0

S E C T I O N 7

SITE SELECTION

SITE SELECTION

7.1 SITE REQUIREMENTS FOR AN EXPERIMENTAL PLANT

The following criteria are being used in the assessment of potential sites for locating an Experimental Reclamation Plant. These may be divided into two categories:

1. Primary Criteria
2. Secondary Criteria

7.1.1 Primary Criteria

These are of basic importance for the selection of a site.

(a) Site must be socially acceptable for the handling of solid waste.

(b) Area must be available for future module expansion. A minimum of 10 acres is recommended.

(c) Ample storage area for solid waste must be available and be socially acceptable.

(d) A traffic pattern must exist for the haulage of solid waste to and from site.

(e) Future plans and life expectancy of site should be known.

7.1.1 (Cont'd)

Discussion - Primary Criteria

(a) Social Acceptance

A site presently being used for refuse handling or disposal is favoured over a new location. Not only is the high cost of land a consideration, but recognition should be given to the possible delays due to social acceptance that may be incurred in obtaining the necessary agreements to commence operating in a new location. An Experimental Reclamation facility should make use of solid waste that is already being accepted into the disposal system before opening new areas of social concern.

(b) Area Available

As the Experimental Reclamation plant is based on a module concept, the area required should not only be sufficient for the initial construction, but should provide adequate adjoining space for future expansion in any direction. A site of 10 to 18 acres is recommended.

(c) Adequate Storage

As a part of the recommended acreage, ample provision should be made for storage of the various components which will be reclaimed from the process. These components may be in the

form of baled or fibrous paper, cardboard, ferrous metals, glass, non-ferrous mixtures, incinerator waste, compost, residue ready for haul to landfill.

It is visualized that the storage areas will be adjacent to the various reclamation modules. The site should be such that this type of short term storage would be socially acceptable.

(d) Traffic Patterns

It is desirable that the site selected utilize the already established traffic pattern for the collection and disposal of solid waste. The established traffic patterns have received social acceptance and are based on the most economical utilization of equipment for short haul to incinerators or transfer stations, and long haul to landfill sites.

(e) Future Plans for Site

In selecting a site the long-term objectives for both the site and the reclamation plant should be compatible. As a number of solid waste handling facilities have a terminal life, the future plans for such sites should be in harmony with a continuing reclamation plant.

7.1.2 Secondary Criteria

Secondary Criteria are those considered of lesser importance and which may cause minor economic or engineering problems which may be overcome.

(a) Configuration of terrain
(b) Accessability to markets
(c) Accessability to rail transportation
(d) Tonnage of waste available
(e) Availability of commercial or industrial waste
(f) Proximity to source of solid waste
(g) Capability of Packer truck delivery of solid waste to the plant.
(h) Site services - power, gas, water, sewers, etc.
(i) Availability of technicians
(j) Proximity to residential areas

Discussion - Secondary Criteria

(a) Terrain

The terrain should be reasonably flat or with a moderate slope from one end to the other so that any change in elevation may be used to advantage in the modular layout of the plant.

Good drainage away from the site is desirable. Soils conditions should be undisturbed and capable of supporting building loads of about 4000 pounds per square foot.

(b) Markets

While accessability to markets is a secondary consideration in locating an Experimental Reclamation Plant, the operating cost of this facility will be increased if the site is located at some distance from existing and potential markets, especially since some revenue will be available on a continuing basis from the primary plant.

In many cases a large transportation burden could be greater than the value of the product recovered and as such would be completely unacceptable in an operating facility, which this plant may become after it has served its experimental function.

The selected site should be accessable to potential users of reclaimed glass, metal or paper products.

(c) Rail Transportation

While rail transportation is not a necessary requirement for an Experimental Plant, it could be desirable for an operating facility handling a large volume of solid waste.

Rail would provide an ideal means of transporting large quantities of reclaimed materials, i.e. metals, glass, paper, back to a user mill.

7.1.2 (Cont'd)

Incoming refuse by rail will dictate design variations to a receiving module to minimize handling.

(d) Available Waste

It is visualized that the Experimental Plant will receive its designed capacity of 200 tons of municipal solid waste per day. Waste will be brought to the plant on a regular basis by packer truck. It may, however, be desirable to run at much higher rates than 200 T/D, e.g. three shift operation would require 600 T/D.

(e) Commercial Waste

Access to commercial and industrial waste as well as municipal waste is desirable for blending various ratios for experimental purposes.

(f) Proximity to Source

It is recognized that the closer to source a material is reclaimed the greater its potential value by reason of transportation, handling and cleaning costs. An initial transportation levy on top of normal operative costs could amount to a sizable increase in operating costs even at the 200 T/D rate. While this would be prohibitive for an operating plant, it might be

acceptable in an experimental facility.

(g) Packer Truck Delivery

It is desirable that solid waste being collected for disposal through the Experimental Plant be received by Packer Truck as this is a design concept of the receiving module. The accessability and regular routing of Packer Trucks becomes a site selection consideration.

(h) Site Services

Ideally the site should be serviced by or be within economic accessability to electric power (4000 H.P. required), natural gas, water (8 in. minimum), sanitary sewer (6 in. minimum).

(i) Technicians

As the plant is to be operated as an experimental facility, it will be staffed by skilled technicians of different training.

The site, through location or appearance, should not in any way be a deterrent to the recruiting of an operating group.

(j) Residential Areas

It is recognized that the establishment of a new solid waste handling facility close to any residential area, regardless of the present use of the site, could lead to social rejection.

7.1.2 (Cont'd)

While designs will incorporate all the latest technology in air, water and noise pollution abatement, there is a distinct possibility that residential neighbours particularly would find objection to its establishment.

7.2 SITE SELECTION FOR AN EXPERIMENTAL RECLAMATION PLANT

Taking into consideration all of the above criteria, we recommend that the Experimental Reclamation Plant be located at either a developed landfill site, a major permanent Transfer Station site, or an incinerator site.

These locations will provide ample incoming raw material with which to work, together with a means of disposing of rejects from the plant.

Their social acceptance has already been approved and they can be expected to have sufficient area to accommodate the possible future requirements of an Experimental Plant.

S E C T I O N 8

MANAGEMENT

MANAGEMENT

8.1 GENERAL

Since the main objective of an experimental waste reclamation plant is to act as a facility for furnishing information for the establishment of "reclamation" as an economical alternative to present methods of disposal, it is imperative that the research projects be selected to achieve this as quickly and expeditiously as possible.

Because industry has the detailed technical expertise, the sales and marketing organizations, and established access to existing markets, it becomes imperative that industry participate in the program.

To obtain industry participation will require incentives that offer opportunities for:

* Increasing profits
* Expanding their operation
* Enhancing Public Image
* Long Term Stability

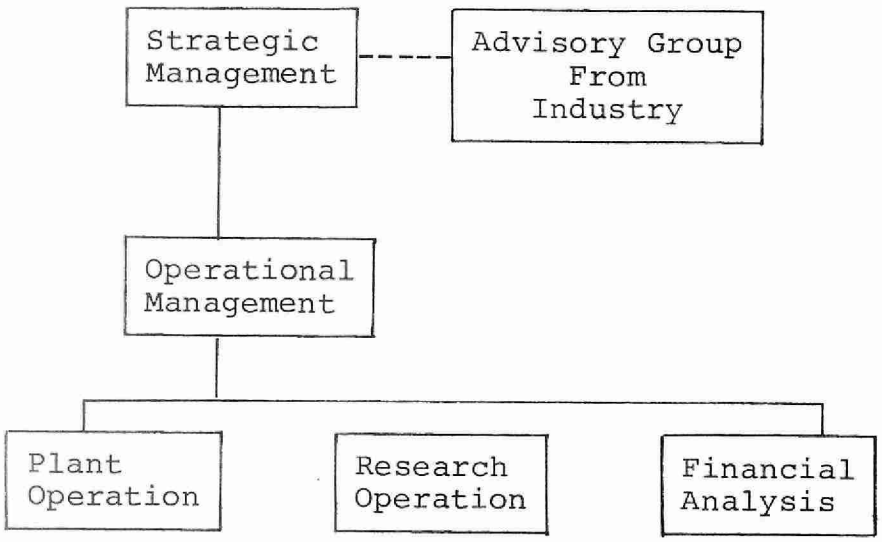
8.2 LEVELS OF MANAGEMENT

It appears that maximum benefit can be obtained from an Experimental Solid Waste Reclamation Plant by establishing two levels of management. These two levels would be:

* A Strategic Management level
* An Operational Management level

8.2 (Cont'd)

A suggested organization chart is shown below:



8.3 STRATEGIC MANAGEMENT

8.3.1 Functions of Strategic Management Level

Would be to:

* Obtain participation by industry.

* Guide and modify the initial long term program to best suit requirements.

* Assess the results of each of the research projects in the light of Canadian requirements.

* Report to the appropriate governmental Ministry regarding progress.

* The strategic management level should be able to respond to the social and cultural requirements of the variety of communities and organizations that will request guidance and information.

* Provide information and guidance to other communities and organizations as required.

* Maintain general public information service that will keep interested groups informed on progress and dispel the many misconceptions usually arising in connection with a project of this nature.

* Provide funding for carrying out the approved research projects.

* Provide instructions for second level of management to carry out specific research projects.

8.3.2 Criteria

Suggested Criteria for selecting the structure best suited for carrying out the functions of strategic management are:

1. Dedication to the attainment of the objectives of the program and capable of devoting full time to it.

2. Since the participation of industry is so critical, it is suggested that strategic management should be held in high regard by industry, particularly the Pulp and Paper, and Metals and Plastics industries.

3. At the same time, it is imperative that no segment receive attention without having regard for the remaining fractions.

4. The Strategic Management group should also be familiar with government procedures for funding, and with the technical assistance available from various government agencies and bodies.

8.4 ADVISORY GROUP FROM INDUSTRY

8.4.1 Functions of Advisory Group from Industry - General

The prime function of this group is to furnish advise and guidance to Strategic Management for obtaining

8.4.1 (Cont'd)

full co-operation and participation by industry and to assist in establishing incentives that will enable the benefits of reclamation to be attained as expeditiously as possible.

The specific contribution that might be expected from this advisory group would be:

* Provide advice regarding marketing problems in both domestic and foreign markets that might arise in connection with transportation, duties, dumping levies or restrictions because of other obscure laws.
* Guidance in establishing the detailed technological and practical limitations for the various fractions of solid waste.
* Assistance in the drafting of terms of reference for requests for proposals from industry.
* Provide advice regarding existing and proposed changes in legislation regarding tax incentives, depletion allowances, etc., which presently favour the use of raw material over reclaimed material.
* Assistance in providing short and long term economic data for long term planning.
* Assistance in providing short and long term domestic and foreign market requirement forecasts.

8.4.2 Criteria

The following criteria are suggested for determining the make-up of the advisory group assisting Strategic Management.

1. Can the members of the advisory group speak for a sufficiently large section of each of the industries?

2. Do the individual members have sufficient information regarding markets, production forecasts, rate of market expansion, etc.?

3. Would the individual members be capable of assessing the magnitude and types of incentives industry would require to become interested in participating?

4. Would the individual members have the confidence of their industry and knowledge to assist in drafting terms of reference for requesting proposals from industry?

5. Would the members selected for each type of industry be able to act impartially and not become involved in a conflict of interests?

6. Would each type of industry representative have sufficient knowledge of the detailed legislation regarding his industry to enable him to make suggestions for any proposed changes?

8.5 OPERATIONAL MANAGEMENT

8.5.1 Functions of Operational Management

General

The operational level of management would be responsible for the actual operation of the plant, conduct of the

8.5.1 (Cont'd)

research and monitoring operation, environmental control, and accuracy and reliability of the economic data. Specifically they would have:

* Responsibility for plant operation and maintenance within prescribed budgetary limits.
* Responsibility for having the research programs carried out.
* Provision of proper data and reports for the first management level.
* Provide continuous flow of information on developing technology for the first management level.
* Provide data to Strategic Management regarding plant limitations affecting specific projects.
* Provide cost estimates, plant changes required and schedules for carrying out specific research projects.

8.5.2 Operational Management Options

* Management by one individual.
* Management by a Management Consultant.
* Management by a private industrial firm.
* Management by Disposal Branch of Metro Toronto Works Department.
* Management by Consulting Engineer.
* Management by the Province of Ontario Department of the Environment.

8.5.3 Criteria

Suggested Criteria for choosing the options open for operational management.

* Management Capability.
* Ability to communicate.
* Knowledge of solid waste management.
* Dedication to the principles of reclamation and to the success of the project.
* Knowledge of Economics and Cost Analysis.
* Knowledge of industrial processes pertaining to the materials in solid waste.
* Knowledge of industries and markets involved.
* Knowledge of existing and developing technology pertaining to solid waste.
* Knowledge of environmental aspects of solid waste reclamation and disposal.
* Knowledge of plant operation and research.
* Creative ability.
* Financial and social stability.

It is suggested that care be exercised in the choice of an option to avoid any that might:

* Result in management that would heavily favour one reclaimed product to the detriment of others.
* Result in management whose interests in promoting the use of reclaimed materials could conflict with an interest in using new material.
* Result in management that would too heavily favour the research aspects to the detriment of establishing practical reclamation techniques for immediate use.

S E C T I O N 9

OPERATING PROCEDURES

OPERATING PROCEDURES

9.1 GENERAL

Complete plant personnel would be briefed on detailed start-up procedure, possible problem areas, alarms and communication systems, emergency shut-downs, safety procedures and fire protection.

Plant personnel would also receive detailed copies of start-up procedure and daily briefing prior to start-up. (It will probably be necessary to modify the daily schedule to adjust to unforeseen circumstances.)

Prior to start-up all equipment would require complete safety checks.

9.2 START-UP

Start-up will begin by running individual pieces of equipment at no load checking bearings, motor loads, R.P.M., rotation, running clearances, safety checks, fastenings and anchor bolts.

Some installation defects will appear at this point and will require correction.

When each piece of equipment can run satisfactorily at no load, similar checks will be initiated with all equipment interlocks functioning and all equipment running at no load.

9.2 (Cont'd)

When the engineer is satisfied that all equipment can operate properly, operation can begin.

9.3 INITIAL OPERATIONS

The initial operation will consist of a series of partial load operations for specified periods of time followed by complete checks of all functions of each piece of equipment.

When satisfactory equipment operation has been established, plant can be operated at full capacity for a specified period of time to establish an efficient basic operation, develop maintenance requirements to enable a preventative maintenance program to be initiated and allow plant personnel to become familiar with the operation.

9.4 INITIAL RESEARCH PROGRAMS

Initial research programs will be compatible with the start-up and initial operations in which calibration of instrumentation can be verified, data collection and processing can be initiated during both start-up and subsequent operation. The initial research will be to determine the capability and accuracy of material balances, materials quality, horsepower consumption of various units verus material processed, unit operating costs for

reclamation, assessment of environment quality in terms of possible air, water and land pollution.

9.5 CONTINUING RESEARCH PROGRAMS

After a comprehensive assessment of the existing plant operation, a detailed continuing program can be undertaken to:

1. Improve plant efficiency.
2. Develop reliable data and operation for energy recovery.
3. Develop reliable data on make-up of solid waste and trends.
4. Develop data on composting with and without sewage sludge, and with and without agricultural waste.
5. In conjunction with industry, develop the material recovery processes which is the long term goal of the facility.

SECTION 10

CAPITAL COST ESTIMATES

10.1 CAPITAL COST ESTIMATES - EXPERIMENTAL RECLAMATION PLANT

Area	Description	Total in Thousandths
111	Site Preparation	$ 20.0
121	Water System and Fire Protection	50.0
131	Gas Supply	10.0
141	Roads and Parking	50.0
151	Storm and Sanitary Sewers	50.0
162	Surface Mobile	30.0
171	Fencing and Security	8.0
	Laboratory, Control Room and Offices	
201	- Building	105.0
202	- Equipment	209.0
	Receiving and Paper Recovery	
211	- Building	740.0
212	- Equipment	483.5
	Shredder	
221	- Building	99.5
222	- Equipment	220.3
	Air Classifier	
231	- Building	69.0
232	- Equipment	389.4
	Interbuilding Conveyors	
251	- Structure	20.0
252	- Equipment	113.4
	Metal Reclamation Centre	
261	- Building	520.0
262	- Equipment	316.6
	Energy Conversion Module	
311	- Building	67.1
312	- Equipment	781.9

10.1 (Cont'd)

Area	Description	Total in Thousandths	
	Composting Module		
411	- Building	$ 73.0	
412	- Equipment	367.9	
512	Instrumentation and Controls	200.0	
612	Electrical Distribution - 4000 H.P. x 140.00	560.0	
			$5,598.6
712	Contingencies at 10%		559.8
			6,158.4
813	Engineering, Construction, Supervision and Expenses		615.8
			6,774.2
912	Cost of Land		1,000.0
	Estimated Total		$7,774.2

10.1.1 Capital Costs - Buildings

Area - 201

Laboratory Control Room and Offices Building — 3000 S.F. x 50.00 = $ 150,000.00

Area 211 - Receiving and Paper Recovery

Vol. 92' x 160' x 33' = 486,000

23' x 58' x 87' = 106,000

592,000 x 1.25 = 740,000.00

Area 221 - Shredder Building

Vol. 29' x 54' x 47' = 73,600 x 1.35 = $ 99,500.00

Area 231 - Air Classifier Building

Vol. 45' x 32' x 40' = 57,500 x 1.25 = 69,000.00

Area 261 - Metals Extraction Building

Vol. 66' x 180' x 35' = 415,000 x 1.25 = 520,000.00

Area 311 - Energy Conversion Building

Vol. 108' x 21' x 40' = 908,000 x 1.25 = 67,100.00

Area 411 - Composting Module

Vol. 24' x 90' x 27' = 58,300 x 1.25 = 73,000.00

Interbuilding Conveyor Housing = 20,000.00

Total for Buildings $1,738,600.00

10.1.2 Capital Costs - Equipment

Area	Labour	Material	Total
212	$ 90,000.00	$ 393,500.00	$ 483,500.00
222	41,000.00	179,300.00	220,300.00
232	72,000.00	317,400.00	389,400.00
252	21,000.00	92,400.00	113,400.00
262	58,600.00	258,000.00	316,600.00
412	68,100.00	299,800.00	367,900.00
312	17,400.00	764,500.00	781,900.00
202	12,000.00	197,000.00	209,000.00
Total	$380,100.00	$2,501,900.00	$2,882,000.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 212 - Receiving and Paper Recovery

Drawing Identification	Account Code	Description	Estimated Cost
1	110	Apron Conveyor 12' x 65' long	$ 71,000.00
2	120	Apron Conveyor 12' x 70' long	76,000.00
3	130	Apron Conveyor 12' x 30' long	21,000.00
4	140	Surge Bin	6,000.00
5	150	Compactors	10,000.00
6	180	Belt Conveyor 6' x 70' long	21,000.00
7	190	Vibrating Conveyor 5' x 105' long	44,000.00
8	200	Manual Separation Station	5,000.00
9	210	Belt Conveyor 3' x 55' long	8,500.00
10	220	Belt Conveyor 6' x 55' long	20,000.00
11	230	Baler (paper)	75,000.00
		Equipment Installation	90,000.00
		Freight and P.S.T.	36,000.00
		Total	$483,500.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 222 - Shredder Building

Drawing Identification	Account Code	Description	Estimated Cost
12	110	Shredder Hood	$ 7,500.00
13	120	Shredder	145,000.00
14	130	Discharge Hopper	3,000.00
15	140	Vibrating Conveyor	7,500.00
		Equipment Installation	41,000.00
		Freight and P.S.T.	16,300.00
		Total	$220,300.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 232 - Air Classifier Building

Drawing Identification	Account Code	Description	Estimated Cost
17	110	Air Classifier	$125,000.00
18	120	Belt Conveyor 6' x 18' long	7,000.00
19	130	Blower	15,000.00
20	140	Cyclone	8,000.00
21	150	Rotary Screen	45,000.00
22	160	Blower	15,000.00
25	170	Belt Conveyor 2' x 25' long	2,500.00
	180 190	Baghouse	35,000.00
	200	Blower	6,000.00
		Ductwork	30,000.00
		Equipment Installation	72,000.00
		Freight and P.S.T.	28,900.00
		Total	$389,400.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 252 - Interbuilding Conveyors

Drawing Identification	Account Code	Description	Estimated Cost
16	110	Belt Conveyor 4' x 210' long	$ 65,000.00
26	120	Belt Conveyor 4' x 75' long	19,000.00
		Equipment Installation	21,000.00
		Freight and P.S.T.	8,400.00
		Total	$113,400.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 262 - Metal Reclamation Centre

Drawing Identification	Account Code	Description	Estimated Cost
36	110	Belt Conveyor 2' x 110' long	$ 22,000.00
27	120	Magentic Separator	20,000.00
28	130	Belt Conveyor 3' x 50' long	10,000.00
29	140	Surge Bin	9,000.00
30	150	Metal Baler	33,500.00
31	160	Belt Conveyor 4' x 90' long	18,000.00
32	170	Portable Manual Separation Station	3,000.00
33	180	Belt Conveyor 4' x 40' long	8,000.00
34	190	Rotary Screen	20,000.00
35	200	Belt Conveyor 2' x 35' long	3,500.00
37	210	3-Way Diverter	5,000.00
38	220	Belt Conveyor 2' x 35' long	3,500.00
39	230	Gravity Table	8,000.00
40	240	Belt Conveyor 2' x 90' long	10,000.00
41	250	Surge Bin	16,000.00
42	260	Belt Conveyor 2' x 45' long	5,000.00
43	270	Belt Conveyor 2' x 400' long	40,000.00
		Equipment Installation	58,600.00
		Freight and P.S.T.	23,500.00
		Total	$316,600.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 412 - Composting Plant

Drawing Identification	Account Code	Description	Estimated Cost
44	110	Belt Conveyor 2' x 18' long	$ 12,000.00
45	120	Agitator - Unloader	70,000.00
47	130	Digester 16' x 16' x 160'	150,000.00
49	140	Belt Conveyor 2' x 25' long	6,000.00
50	150	Belt Conveyor 2' x 105' long	12,000.00
51	160	Shuttle Conveyor 2' x 100' long	22,500.00
		Equipment Installation	68,100.00
		Freight and P.S.T.	27,300.00
		Total	$367,900.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 312 - Energy Conversion Module

Drawing Identification	Account Code	Description	Estimated Cost
23	110	Cyclone	$ 8,000.00
24	120	Storage Bin	60,000.00
53	140	Dust Collector	90,000.00
52	150	Energy Conversion Unit	500,000.00
5	160	Compactor	20,000.00
	180	Bag House	15,000.00
		Equipment Installation	17,400.00
		Freight and P.S.T.	71,500.00
		Total	$781,900.00

10.1.2 (Cont'd)

CAPITAL COST ESTIMATE

Area 202 - Laboratory, Control Room and Offices

Drawing Identification	Account Code	Description	Estimated Cost
	110	Laboratory Equipment (See 4.8.1.2)	$131,500.00
	120	Truck Scales	60,000.00
		Equipment Installation	12,000.00
		Freight and P.S.T.	5,500.00
		Total	$209,000.00

10.2 BASIS OF CAPITAL COST ESTIMATES

10.2.1 Plant Size and Capacity

The Capital Cost Estimate is based on the plant layouts shown and on the buildings being constructed according to the Toronto Building Code. The equipment has been sized to process 200 tons of solid waste in an 8-hour day. An energy recovery module and a composting plant has also been included. The energy recovery module is sized to supply building heat of 16,000,000 BTU/hr. The composting plant can handle 100 tons/day (24 hr. basis) of food and plant waste and sewage sludge in any proportion.

While the selected location of the facility will influence the final Architectural finish of the buildings, (i.e. topography and proximity to existing structures, etc.), the buildings conceived are to be both functional and of a pleasing appearance. Buildings will be of ample size as free as possible of interior columns and obstructions. Walls will be designed to allow ready expansion and connection of future experimental modules.

The plant will have a connected load of approximately 4000 H.P. and it is assumed that all services will be available at the site.

10.2.2 Taxes

10.2.2.1 Federal Sales Tax

No Federal Sales Taxes have been included in process equipment costs as this plant should qualify as a resource recovery plant similar to a mine or refinery.

Federal Sales Tax has been included in costing buildings and building services.

10.2.2.2 Provincial Sales Tax

Ontario Sales Tax of 7% has been included on all building material and equipment used in the plant.

10.2.3 Escalation

No allowance for inflationary trends have been included. Costs are based on 1974 prices and will not be valid in 1975. It has been assumed that contracts will be let in 1974. At the present rate of cost escalation, the cost of this plant will increase at a rate of .8% per month after December 31, 1974, or $52,480.00 per month. It is anticipated that actual construction would take about seven months.

10.2.4 Interest on Capital during Construction

Since the funding of this project will be completely different from a normal commercial enterprise, no charges for interest on Capital during construction have been included.

10.2.5 Overtime Pay

Cost of construction labour has been taken on the basis of straight time pay with no allowance for overtime.

10.2.6 Cost of Land

Land costs of $1,000,000 have been included in the Capital Cost Estimate to cover the acquisition of a 15 - 18 acre site.

10.2.7 Costs of Organization and Incorporation

No incorporation charges for the project have been included in the Capital Cost Estimate.

S E C T I O N 1 1

OPERATING COSTS

SUMMARY OF OPERATING COSTS

11. DIRECT OPERATING COSTS

Direct Wages and Benefits 200,000 x 1.2	$240,000.00	
Maintenance	43,350.00	
Power Costs (Toronto Rates)	90,000.00	
Fuel Costs	48,000.00	
Water and Sewage	6,000.00	
Metals and Chemicals	12,500.00	
Environmental Monitoring	12,000.00	
Direct Operating Costs		$451,850.00

ADMINISTRATIVE COSTS

Salaries and Benefits 41,000 x 1.2	$ 49,200.00	
Office Supplies	2,400.00	
Telephone and Telegraph	720.00	
Postage and Insurance	18,400.00	
		70,720.00
Annual Research Costs (Item 4.8.3)		185,000.00
Total Gross Annual Operating Cost		$707,570.00

SUMMARY OF CREDITS

Recovery of Corrugated Cardboard	$120,000.00	
Recovery of Newsprint	30,000.00	
Recovery of Ferrous Metals	50,000.00	
Credit for fuel saving	28,800.00	
Credit for disposal	41,640.00	
Total Credits		270,440.00
Estimated Net Annual Operating Cost		$437,130.00

11.1 OPERATING COST ESTIMATE

11.1.1 General

Cost of operating a plant of this type has been assumed to be made up of three segments;

Operating Costs

Administrative Costs

Cost of Research Projects

11.1.2 Operating Costs

1. Wages and salaries of operating personnel.
2. Direct supervisory salaries.
3. Maintenance Costs.
4. Costs of services - Power, Water, Fuel, Sewage.
5. Costs of materials and chemicals used in the process.
6. Environmental Monitoring.
7. Credit for Reduction in quantity for disposal.
8. Credit for metal recovered and marketed.

11.1.3 Administrative Costs

1. Management Salary.
2. Clerical staff salaries.
3. Office supplies and equipment.
4. Telephone and Telegraph.
5. Postage and Insurance.
6. Amortization Costs.

11.1.4 Research Project Costs

1. Modifications and additions to the plant.

2. Salaries of extra technical and operating personnel required.

3. Sub-contracts for monitoring and recording research projects (assuming this to be done by O.R.F. or other research group).

11.2 DETAILS OF OPERATING COSTS

11.2.1 Operating Manpower

Area	Description	Operating Minimum Required	Shifts	Total
201	Laboratory, Control Room and Offices	1	1	1
211	Receiving and Paper Recovery	3	1	3
221	Shredder Building	0	1	0
231	Air Classifier Building	1	1	1
261	Metal Reclamation Centre	2	1	2
311	Energy Conversion Module	2	3	6
411	Composting Module Maintenance	1	1	1
				15
	Direct Supervision (by Professional Engineer)	1	1	1

Costs direct wages and benefits
15 x 12,000 = $180,000.00

Supervision
1 x 20,000 = 20,000.00

Total $200,000.00

11.2.2 Maintenance Costs

Calculating maintenance costs on the same basis as mining and other resource recovery operations at 2.5% of Capital Cost for three shift operation.

Plant Maintenance Costs = $\frac{2.5}{300}$ x 2,500,000 = $20,830/yr

Building Maintenance (cleaning, etc.) = $25,000/yr

11.2.3 Power, Fuel, Water and Sewage

Assuming City of Toronto rates for services.

11.2.3.1 Estimated Power Costs

Estimated Connected Load = 4000 K.W.

Estimated Maximum Demand = 3000 K.W.

Estimated Average Continuous Load = 2000 K.W.

11.2.3.2 Estimated Fuel Costs - assuming natural gas as the fuel.

Estimated Maximum Heating Load = 16,000,000 BTU/hr

Degree days = 7,000/yr

Fuel Costs - natural gas @ 1.25/1000 C.V. piped to various buildings.

$$\text{Fuel Costs} = \frac{16,000,000}{70} \times \frac{7,000}{1,000,000} \times \frac{1.25}{} \times 24$$

= $48,000/yr

11.2.3.3 Water and Sewage

Estimated - $6,000/yr.

11.2.4 Cost of Materials and Chemicals used in Process

Allow - 25¢/ton material processed

50,000 T/yr @ 25¢ = $12,500/yr

11.2.5 Cost of Environmental Monitoring

Regular monitoring of particulate discharge from air collection devices is assumed to be a normal plant operating cost.

Allowance - $12,000/yr

11.2.6 Credit for Reduction in Volume

Credit for reduction in volume to be landfilled will start at zero during the start-up period immediately going to 6% when clean corrugated cardboard and newsprint is recovered and reach a possible maximum of 90% to 95%.

11.2.7 Credit for Material Recovered and Marketed or Used

At present prices, recovered corrugated and newsprint should give annual income of:

3% Corrugated Cardboard @ 80.00/T = $\frac{3}{100}$ x 80 x 50,000

= $120,000

3% Newsprint @ 20/00/T = $\frac{5}{100}$ x 20.00 x 40,000

= $ 30,000

5% Ferrous Metals @ 20.00/T = $\frac{5}{100}$ x 20.00 x 50,000

= $ 50,000

If 60% of fuel used is from waste credit

$\frac{60}{100}$ x 48,000 = $ 28,800

11.2.7 (Cont'd)

Tonnage Not required to be disposed.

11% Material Recovered = $\frac{11}{100}$ x 50,000 = 4,500 Tons/yr

Fuel used = 1,440 Tons/yr

Total 6,940 Tons/yr

Credit for saving on disposal cost @ 6.00/Ton
= $41,640.00.

11.3 DETAILS OF ADMINISTRATIVE COSTS

1. Management Salary		$25,000.00/yr
2. Clerical Staff		
1 Typist	$ 6,000.00/yr	
1 Bookkeeper	10,000.00/yr	
Total	$16,000.00/yr	$16,000.00/yr
3. Office Supplies and Equipment @ $200.00/month x 12		$ 2,400.00/yr
4. Telephone and Telegraph @ $60.00/month x 12		$ 720.00/yr
5. Postage and Insurance @ $20.00/month x 12	$ 240.00/yr $16,000.00/yr	
	$18,400.00	$18,400.00/yr

6. Amortization Charges

Since this plant represents an experimental facility, no amortization costs are included in administrative costs.

11.4 COST OF RESEARCH PROJECTS

Since the whole program of developing a successful reclamation process will involve a series of research

projects, many of them interdependent, it is assumed that each segment will have a purpose, method, result and conclusion within a limited budget and time frame.

S E C T I O N 1 2

PROJECT SCHEDULE

PROJECT SCHEDULE

12.1 GENERAL

The synopsized bar chart showing the schedule is based on deliveries we are presently experiencing on other major projects and will only be valid for a short period.

Deliveries are, of course, in a continual state of flux with shortened completion schedules sometimes available at slightly higher costs.

12.2 Schedules for construction materials are presently as follow:

Redi-Mix Cement	Immediate
Structural Steel	12 to 14 weeks
Glass	8 weeks
Roofing Material	12 to 16 weeks
Siding	12 to 16 weeks
Reinforcing Bar	6 to 8 weeks

12.3 Equipment delivery schedules are based on the following:

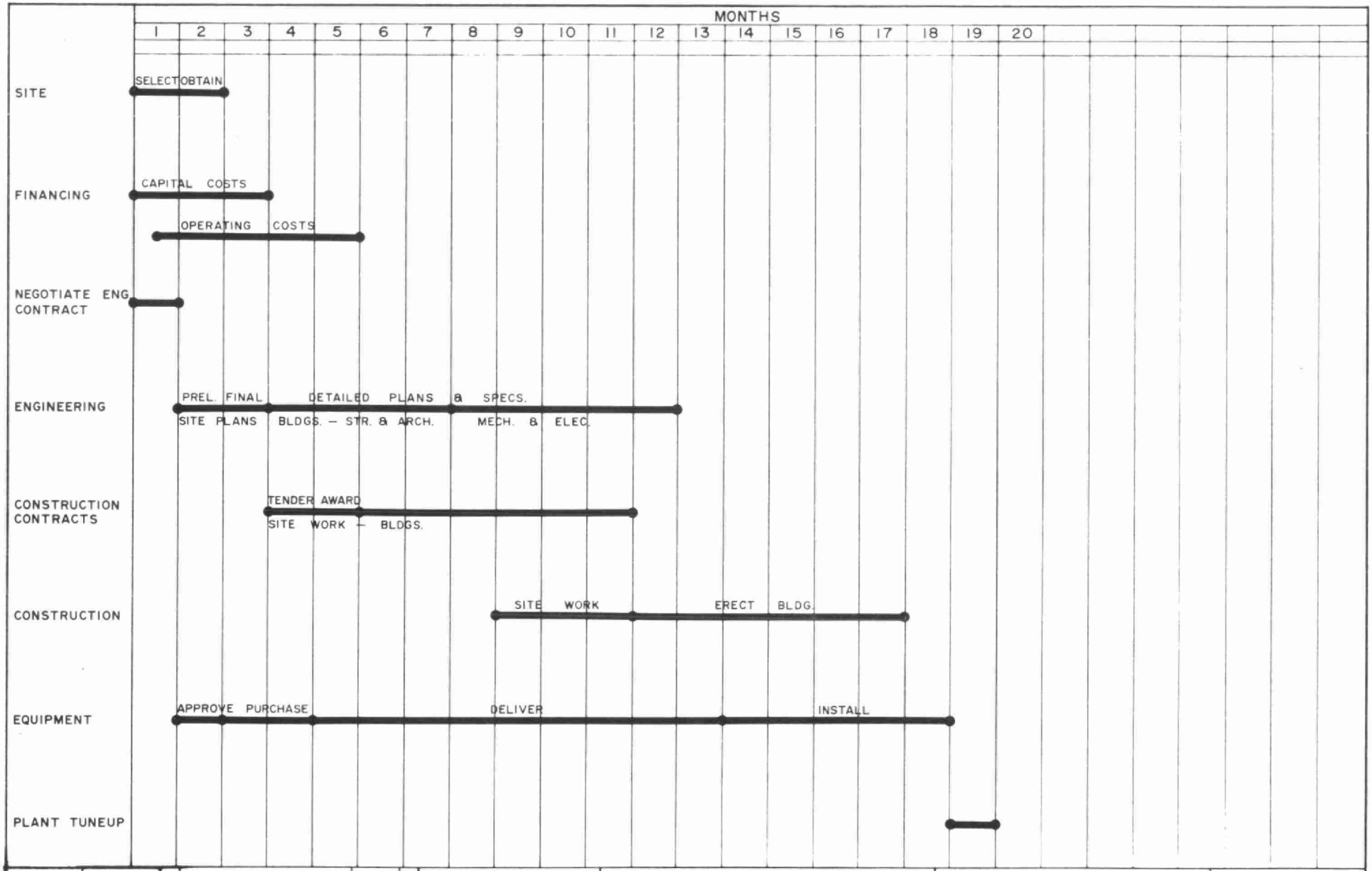
Hammermill	36 to 40 weeks
2200 Volt Motors	24 to 30 weeks
2200 Volt Motor Control Centre	24 weeks
Main Transformers	30 weeks
Unit Subs	24 weeks
Conveyors	12 to 14 weeks
Tanks, 6 foot diameter	8 weeks

12.3 (Cont'd)

Tanks - over 6 feet	14 weeks plus erection
Cyclones	12 weeks
Boilers	12 to 14 weeks
Chutes	8 to 12 weeks
Vibrating Feeders	18 to 20 weeks
Heat Exchanger	12 weeks
Compressors up to 100 cfm	6 to 8 weeks
Fans and Blowers	10 to 12 weeks
Drives and V Belts	12 weeks
Process Control Panels	20 to 24 weeks
Large Process Pumps	26 to 28 weeks
Small Pumps	10 to 12 weeks
Sewer Pipe	12 to 16 weeks
Weightomers Belt Conveyor	12 to 16 weeks

Because of the lengthy delivery on high Voltage Switch-gear and the main shredder and normal tendering and selection procedures required for purchasing, our minimum estimated time lapse from the beginning of detailed engineering to plant start-up would be 18 months.

It may, however, be possible to considerably shorten the time lapse by pre-purchasing the critical long-delivery items immediately that the decision to proceed has been made.



DWG No	REF DWGS	NO.	DESCRIPTION	DATE	BY
		REVISIONS			

SECTION
SCALE — DATE
DESIGNED BY
DRAWN BY
CHECKED BY — APR 9,74
APPROVED BY

CLIENT:
ONTARIO MINISTRY OF THE ENVIRONMENT
LOCATION: TORONTO - CANADA

KILBORN
KILBORN ENGINEERING LTD.
THIRTY SIX PARK LAWN RD.
TORONTO 530, ONT. CANADA
416, 252 - 101 TELEX 02-2798

TITLE
RESOURCE RECOVERY CENTRE
EXPERIMENTAL WASTE RECLAMATION PLANT
PROJECT SCHEDULE

ACCT No.
PROJECT No. 982
DIVISION No. 15
DRAWING NUMBER
REV

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